AQUATIC EFFECTS TECHNOLOGY EVALUATION (AETE) PROGRAM

1997 Field Program
Final Report
Myra Falls Mine Site,
British Columbia

AETE Project 4.1.3

September 1998
Revised as of March 1999

1997 FIELD PROGRAM - AETE
MYRA FALLS OPERATIONS

SITE REPORT

Report prepared for:

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SITE REPORT

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AQUATIC EFFECTS TECHNOLOGY EVALUATION PROGRAM

Notice to Readers

1997 Field Program

The Aquatic Effects Technology Evaluation (AETE) program was established to review appropriate technologies for assessing the impacts of mine effluents on the aquatic environment. AETE is a cooperative program between the Canadian mining industry, several federal government departments and a number of provincial governments; it is coordinated by the Canada Centre for Mineral and Energy Technology (CANMET). The program is designed to be of direct benefit to the industry, and to government. Through technical evaluations and field evaluations, it will identify cost-effective technologies to meet environmental monitoring requirements. The program includes three main areas: acute and sublethal toxicity testing, biological monitoring in receiving waters, and water and sediment monitoring. The program includes literature-based technical evaluations and a comprehensive three year field program.

The program has the mandate to do a field evaluation of water, sediment and biological monitoring technologies to be used by the mining industry and regulatory agencies in assessing the impacts of mine effluents on the aquatic environment; and to provide guidance and to recommend specific methods or groups of methods that will permit accurate characterization of environmental impacts in the receiving waters in as cost-effective a manner as possible. A pilot field study was conducted in 1995 to fine-tune the study design.

A phased approach has been adopted to complete the field evaluation of selected monitoring methods as follows:

Phase I: 1996- Preliminary surveys at seven candidate mine sites, selection of sites for further work and preparation of study designs for detailed field evaluations.

Phase II: 1997-Detailed field and laboratory studies at selected sites.

Phase III: 1998- Data interpretation and comparative assessment of the monitoring methods: report preparation.

Phases II and III are the focus of this report. The objective of the 1997 Field Program is NOT to determine the extent and magnitude of effects of mining at the sites but rather to test a series of hypotheses under field conditions and evaluate monitoring methods for assessing aquatic effects.

In Phase I, the AETE Technical Committee selected seven candidates mine sites for the 1996 field surveys: Myra Falls, Westmin Resources (British Columbia); Sullivan, Cominco (British Columbia); Lupin, Contwoyto Lake, Echo Bay (Northwest Territories); Dome, Placer Dome Canada (Ontario); Levack/Onaping, Inco and Falconbridge (Ontario); Gaspé Division, Noranda Mining and Exploration Inc. (Québec); Heath Steele Division, Noranda Mining and Exploration Inc. (New-Brunswick).

Study designs were developed for four sites that were deemed to be most suitable for Phase II of the field evaluation of monitoring methods: Myra Falls, Dome, Heath Steele, Lupin. Lupin was subsequently dropped based on additional reconnaissance data collected in 1997. Mattabi Mine, (Ontario) was selected as a substitute site to complete the 1997 field surveys.

A summary of the results and comparisons of tools at all the four mine sites studied in 1997 are provided in a separate document which evaluate the cost-effectiveness of each monitoring tool (AETE Report #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998)

For more information on the monitoring techniques, the results from their field application and the final recommendations from the program, please consult the *AETE Synthesis Report*.

Any comments regarding the content of this report should be directed to:

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PROGRAMME D'ÉVALUATION DES TECHNIQUES DE MESURE D'IMPACTS EN MILIEU AQUATIQUE

Avis aux lecteurs

Études de terrain - 1997

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA) vise à évaluer les différentes méthodes de surveillance des effets des effluents miniers sur les écosystèmes aquatiques. Il est le fruit d'une collaboration entre l'industrie minière du Canada, plusieurs ministères fédéraux et un certain nombre de ministères provinciaux. Sa coordination relève du Centre canadien de la technologie des minéraux et de l'énergie (CANMET). Le programme est conçu pour bénéficier directement aux entreprises minières ainsi qu'aux gouvernements. Par des évaluations techniques et des études de terrain, il permettra d'évaluer et de déterminer, dans une perspective coût-efficacité, les techniques qui permettent de respecter les exigences en matière de surveillance de l'environnement. Le programme comporte les trois grands volets suivants : évaluation de la toxicité aiguë et sublétale, surveillance des effets biologiques des effluents miniers en eaux réceptrices, et surveillance de la qualité de l'eau et des sédiments. Le programme prévoit également la réalisation d'une série d'évaluations techniques fondées sur la littérature et d'évaluation globale sur le terrain.

Le Programme ÉTIMA a pour mandat d'évaluer sur le terrain les techniques de surveillance de la qualité de l'eau et des sédiments et des effets biologiques qui sont susceptibles d'être utilisées par l'industrie minière et les organismes de réglementation aux fins de l'évaluation des impacts des effluents miniers sur les écosystèmes aquatiques; de fournir des conseils et de recommander des méthodes ou des ensembles de méthodes permettant, dans une perspective coût-efficacité, de caractériser de façon précise les effets environnementaux des activités minières en eaux réceptrices. Une étude-pilote réalisée sur le terrain en 1995 a permis d'affiner le plan de l'étude.

L'évaluation sur le terrain des méthodes de surveillance choisies s'est déroulée en trois étapes:

Étape I — 1996 - Évaluation préliminaire sur le terrain des sept sites miniers candidats, sélection des sites où se poursuivront les évaluations et préparation des plans d'étude pour les évaluations sur le terrain.

Étape II — 1997- Réalisation des travaux en laboratoire et sur le terrain aux sites choisis

Étape III — 1998 -Interprétation des données, évaluation comparative des méthodes de surveillance; rédaction du rapport.

Ce rapport vise seulement les résultats de l'étape II et III. L'objectif du projet <u>N'EST PAS</u> de déterminer l'étendue ou l'ampleur des effets des effluents miniers dans les sites. Le projet vise à vérifier une série d'hypothèses sur le terrain et à évaluer et comparer un ensemble choisi de méthodes de surveillance.

À l'étape I, le comité technique ÉTIMA a sélectionné sept sites miniers candidats aux fins des évaluations sur le terrain:Myra Falls, Westmin Resources (Colombie-Britannique); Sullivan, Cominco (Colombie-Britannique); Lupin, lac Contwoyto, Echo Bay (Territoires du Nord-Ouest); Levack/Onaping, Inco et Falconbridge (Ontario); Dome, Placer Dome Mine (Ontario); Division Gaspé, Noranda Mining and Exploration Inc.(Québec); Division Heath Steele Mine, Noranda Mining and Exploration Inc.(Nouveau-Brunswick).

Des plans d'études ont été élaborés pour les quatres sites présentant les caractéristiques les plus appropriées pour les travaux prévus d'évaluation des méthodes de surveillance dans le cadre de l'étape II (Myra Falls, Dome, Heath Steele, Lupin). Toutefois, une étude de reconnaissance supplémentaire au site minier de Lupin a révélé que ce site ne présentait pas les meilleures possibilités. Le site minier de Mattabi (Ontario) a été choisi comme site substitut pour compléter les évaluations de terrain en 1997.

Un résumé des résultats obtenus aux quatre sites miniers en 1997, la comparaison et l'évaluation des techniques dans une perspective coût-efficacité sont présentés dans un autre document (Rapport ÉTIMA #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998).

Pour des renseignements sur l'ensemble des outils de surveillance, les résultats de leur application sur le terrain et les recommandations finales du programme, veuillez consulter le *Rapport de synthèse ÉTIMA*.

Les personnes intéressées à faire des commentaires sur le contenu de ce rapport sont invitées à communiquer avec M^me^ Geneviève Béchard à l'adresse suivante :

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EXECUTIVE SUMMARY

The Myra Falls (British Columbia) mine site study is one of four field evaluations carried out in 1997 under the Aquatic Effects Technology Evaluation (AETE) Program, a joint government-industry program to evaluate the cost-effectiveness of technologies for the assessment of mining-related impacts in the aquatic environment. The other three mines studied were Dome (Ontario), Mattabi (Ontario) and Heath Steele (New Brunswick). Results of all four studies are summarized and evaluated in a separate summary report.

The Myra Falls operations of Boliden (Westmin) are located in central Vancouver Island, and produce base metal concentrates (zinc, copper, lead) as well as gold and silver. The operations discharge treated effluent to Myra Creek and seepages from other sources at the mine reaches Myra Creek, which flows into Buttle Lake, a large, deep impoundment in the Campbell River watershed. The mine historically discharged tailings into the south end of Buttle Lake (until the mid-1980s).

The objectives of the 1997 field program were to test 13 hypotheses formulated under four guiding questions:

1. are contaminants getting into the system (and to what degree and in which compartments)?
2. are contaminants bioavailable?
3. is there a measurable (biological) response? and
4. are contaminants causing the responses?

The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer these four general questions about mine effect. The evaluation of tools included: sediment monitoring (sediment toxicity tests); fish monitoring (tissue metallothionein and metal analyses, and population/community indicators), and; integration of tools (relationships between exposure and biological responses and use of effluent sublethal toxicity).

Of the 13 hypotheses, 6 were tested at Myra Falls as outlined in Table 1.1. The remaining seven hypotheses not tested at Myra Falls related to responses in fish. Fish sampling was not included at Myra Falls because it was concluded that the site conditions were less optimal to test fish hypotheses than at the other three mine sites tested in 1997.

The sediment quality triad was used as an additional means of evaluating the linkages between sediment toxicity, sediment chemistry and benthic community response (H10 and H11) in Buttle Lake. The triad provides a more holistic means of evaluating the tools.

Study Design

A reconnaissance survey was carried out in Myra Creek and Buttle Lake to assess the feasibility of collecting fish and benthos in Myra Creek, to identify metal concentration gradients in Buttle Lake sediments, and to assess the abundance of benthic invertebrates in the profundal zone of the lake. The final study design was formulated based on the results of this reconnaissance.

The study design at Myra Falls was based on lake sampling for benthos, sediment chemistry and sediment toxicity using a nearfield-farfield-reference design. The nearfield area was in southern Buttle Lake, the farfield in northern Buttle Lake, and nearby Brewster Lake served as a reference. Seven stations were sampled within each of the three areas.

Sampling in Myra Creek followed a reference-exposure (Control-Impact) design, and allowed for qualitative testing of benthos-water quality and effluent toxicity-benthos hypotheses. Ten stations were sampled for benthos in ruffle areas within each of the two sampling areas.

Sampling Program

The field survey at Myra Falls was completed in mid-September 1997, and included:

- water sampling in Myra Creek and Buttle Lake in each sampling area for determination of dissolved (0.45 micron filtered) and total metal concentrations. Only the Myra Creek water quality data were used in hypothesis testing;

- surficial sediment sampling at 21 profundal lake stations (3 areas) using a petite Ponar, for determination of "total" metal concentrations, partial metal concentrations (i.e., the Fe and Mn oxide-bound fraction) and concentrations of acid volatile sulphide (AVS) and simultaneously extracted metals (SEM);

- surficial sediment sampling at the above 21 stations for benthic macroinvertebrate community analysis and for sediment toxicity testing (*Hyalella azteca* survival and growth, *Chironomus riparius* survival and growth, *Tubifex tubifex* survival and growth);

- benthic macroinvertebrate sampling in stream riffles at ten effluent-exposed stations and ten reference stations in Myra Creek using a T-sampler; and

- testing of chronic effluent toxicity, based on four samples of final effluent from the mine. Tests included *Ceriodaphnia dubia* survival and reproduction, fathead minnow survival and growth, *Selenastrum capricornutum* growth and *Lemna minor* growth.

Data Overview

Water Quality

Zinc and copper concentrations in Myra Creek were greater than Canadian Water Quality Guidelines (CWQGs) downstream of the mine, and indicated a metal source from Myra Falls. Much of the metal loading appeared to originate from sources other than the treated effluent.

Concentrations of zinc were also elevated in the nearfield area of Buttle Lake, with maximum values approximating the CWQG value. Metal concentrations were lower in the farfield and lowest in the reference area.

Dissolved and total metal concentrations showed similar spatial patterns and generally similar values for key metals (Zn, Cu, Cd). There was some evidence of minor sample contamination in dissolved metal samples.

Sediment Chemistry

Sediment total metal concentrations were highest in the nearfield, lower in the farfield and lowest in the reference area (Zn, Cu, Cd, Pb, As). Concentrations of all of these metals exceeded the Canadian Interim Sediment Quality Assessment Values, especially in the nearfield area where concentrations were greater than the probable effect level (PEL) values. Partial metal concentrations followed a similar spatial pattern, although the partial metal fraction generally accounted for a relatively small portion of the total concentrations.

The SEM/AVS molar ratios in sediments were highly variable within areas, and were generally greatest at nearfield stations, lower at farfield stations, and lowest at reference stations. The results implied that nearfield sediments, and to a lesser extent farfield sediments, are potentially toxic to sediment-dwelling organisms.

Sediment Toxicity

Nearfield, farfield and reference lake sediments showed different degrees of toxicity to *Chironomus, Hyalella* and *Tubifex*. Nearfield sediments were toxic to the former two species in terms of survival and growth. *Hyalella* also showed a survival and growth response in farfield sediments relative to the reference site. No response was seen in *Tubifex* survival, and reproductive responses to nearfield and farfield sediments were minor.

Benthic Macroinvertebrates

Benthic macroinvertebrates did not respond to exposure to metal-enriched sediments in terms of densities of organisms, numbers of taxa present or the abundance of chironomids. Harpactacoids and *Pisidium*, however, were nearly absent in the exposure area (Buttle Lake) but were common in the reference area (Brewster Lake).

Reference-exposure differences in Myra Creek benthos were relatively small, and included slightly reduced organism densities, numbers of taxa and numbers of sensitive EPT taxa (**E**phemeroptera-**P**lecoptera-**T**richoptera) at the exposed stations.

Effluent Toxicity

Myra Falls effluent was non-toxic to fathead minnow. Chronic IC25 values were similar for *Ceriodaphnia, Selenastrum* and *Lemna*. That is, reproduction (*Ceriodaphnia*) or growth (the other species) was inhibited by 25% when exposed to 35% to 45% effluent on average.

Hypothesis Testing

Hypothesis testing results are summarized in Table 5.2. Results of testing indicate that measurable biological responses occur at Myra Falls and that contaminants (metals) appear to cause these biological responses.

Technology Evaluation

Overall, most of the monitoring tools evaluated at Myra Falls were effective in demonstrating a mine effect, with the exception of the fathead minnow chronic toxicity test and the SEM/AVS analysis. Of the tools that were effective, some were slightly more effective than others as predictors of biological response. A summary of the effectiveness of various monitoring tools tested at Myra Falls is presented in Table 6.2. Table 6.3 provides a comparison of the effectiveness of similar tools in measuring aquatic effects at Myra Falls.

Conclusions on the cost-effectiveness of the tools based on results from all four mine sites studied in 1997 are found in a separate document "Summary and Cost-Effectiveness of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program."

SOMMAIRE

L'étude du site de la mine Myra Falls (Colombie-Britannique) est l'une des quatre évaluations sur le terrain effectuées en 1997 dans le cadre du Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ETIMA), programme conjoint gouvernement-industrie destiné à évaluer le rapport coût-efficacité des technologies d'évaluation des impacts liés aux activités minières dans le milieu aquatique. Les trois autres sites miniers étudiés étaient ceux de Dome (Ontario), de Mattabi (Ontario) et de Heath Steele (Nouveau-Brunswick). On présente un résumé et une évaluation des résultats de ces quatre études dans un rapport sommaire distinct.

Les installations minières de la mine Myra Falls de Boliden (Westmin) sont situées au centre de l'île de Vancouver et produisent des concentrés de métaux communs (zinc, cuivre, plomb), ainsi que de l'or et de l'argent. Elles rejettent des effluents traités dans le ruisseau Myra; des eaux d'infiltration d'autres provenances rejoignent le ruisseau Myra, qui se déverse dans le lac Buttle, une vaste et profonde retenue du bassin hydrographique de la rivière Campbell. Jusque vers le milieu des années 80, la mine rejetait ses résidus dans l'extrémité sud du lac Buttle.

Les objectifs du programme sur le terrain de 1997 étaient de vérifier 13 hypothèses formulées pour tenter de répondre à quatre questions principales :

1. Est-ce que les contaminants pénètrent dans le réseau aquatique (et dans l'affirmative, dans quelle mesure et dans quels compartiments)?
2. Les contaminants sont-ils biodisponibles?
3. La réponse (biologique) est-elle mesurable?
4. Les contaminants sont-ils la cause de ces réponses?

Ces hypothèses représentent des questions plus spécifiques concernant la capacité (relative) des différents outils de surveillance de répondre à ces quatre questions générales sur les effets des activités minières. L'évaluation des outils prévoyait notamment la surveillance des sédiments (tests de toxicité des sédiments), la surveillance des poissons (dosage de la métallothionéine et des métaux dans les tissus et la détermination des indicateurs des populations/communautés) et, enfin, l'intégration des outils (rapports entre l'exposition et les réponses biologiques et utilisation de la toxicité sublétale des effluents).

On a vérifié 6 des 13 hypothèses au site de la mine Myra Falls (voir le tableau 1.1). Les 7 hypothèses non vérifiées à ce site étaient liées aux réponses des poissons. On n'a pas prévu d'échantillonnage de poissons au site Myra Falls parce qu'on a conclu que les conditions de ce site étaient moins qu'optimales pour vérifier les hypothèses concernant les poissons, par rapport aux trois autres sites miniers étudiés en 1997.

On a utilisé les trois paramètres de la qualité des sédiments comme outil supplémentaire pour l'évaluation des liens entre la toxicité des sédiments, la chimie des sédiments et la réponse de la communauté benthique (H10 et H11) dans le lac Buttle. Ces trois paramètres donnent une vue plus générale pour l'évaluation des outils.

Plan de l'étude

On a effectué un relevé de reconnaissance au site du ruisseau Myra et du lac Buttle afin d'évaluer la faisabilité de recueillir des poissons et du benthos dans le ruisseau Myra, de déterminer les gradients de concentration des métaux dans les sédiments du lac Buttle et d'évaluer l'abondance des invertébrés benthiques dans la zone profonde du lac. Les résultats de ce relevé ont servi de base pour la formulation du plan final de l'étude.

Le plan de l'étude du site Myra Falls était basé sur l'échantillonnage du benthos du lac, ainsi que sur la chimie et la toxicité de ses sédiments, selon un modèle zone voisine - zone éloignée -zone de référence. La zone voisine était la partie sud du lac Buttle, la zone éloignée, la partie nord du lac Buttle, et le lac Brewster voisin a servi de zone référence. On a effectué des échantillonnages à sept stations choisies dans chacune des trois zones.

Pour l'échantillonnage au ruisseau Myra, on a utilisé un modèle zone de référence (témoin) – zone d'exposition (impact) permettant d'effectuer des tests de qualité du benthos et de l'eau, ainsi que de vérifier les hypothèses concernant la toxicité des effluents et le benthos. On a échantillonné le benthos à 10 stations situées dans des rapides, dans chacune des deux zones d'échantillonnage.

Programme d'échantillonnage

On a terminé les relevés sur le terrain à Myra Falls vers la mi-septembre 1997, et notamment :

- l'échantillonnage de l'eau du ruisseau Myra et du lac Buttle dans chacune des zones d'échantillonnage pour le dosage des métaux dissous (filtre de 0,45 micron) et totaux. Pour la vérification des hypothèses, on n'a utilisé que les données de qualité de l'eau du ruisseau Myra;

- l'échantillonnage des sédiments des eaux de surface à 21 stations du lac en eau profonde (3 zones) à l'aide d'un échantillonneur « Petite Ponar » pour la détermination des concentrations « totales » et partielles de métaux (c.-à-d. la fraction liée aux oxydes de Fe et de Mn), ainsi que des concentrations des sulfures volatiles en milieu acide et des métaux extractibles simultanément;

- l'échantillonnage des sédiments des eaux de surface aux 21 stations ci-dessus pour l'analyse des communautés de macroinvertébrés benthiques et pour déterminer la toxicité des sédiments (survie et croissance d'*Hyalella azteca*, de *Chironomus riparius* et de *Tubifex tubifex*);

- l'échantillonnage des macroinvertébrés benthiques dans les zones de rapides de 10 stations exposées aux effluents et de 10 stations de la zone référence du ruisseau Myra, à l'aide d'un échantillonneur en T;

- la détermination de la toxicité chronique des effluents, d'après 4 échantillons d'effluents miniers finals (notamment : survie et reproduction de *Ceriodaphnia dubia*, survie et croissance de la tête-de-boule, croissance de *Selenastrum capricornutum* et croissance de *Lemna minor*.

Aperçu des données

Qualité de l'eau

Les concentrations de zinc et de cuivre du ruisseau Myra dépassaient les limites des Recommandations pour la qualité des eaux du Canada (RQEC) en aval du site de la mine, ce qui indiquait l'existence d'une source de métaux provenant du site Myra Falls. Une bonne partie des charges de métaux semblaient provenir de sources autres que l'effluent traité.

Les concentrations de zinc dans la zone voisine du lac Buttle étaient plus élèvées, dont les valeurs maximales étaient voisines des limites des RQEC. Les concentrations de métaux étaient plus faibles dans la zone éloignée et les valeurs les plus faibles étaient observées dans la zone de référence.

Les profils de distribution spatiale des concentrations de métaux dissous et totaux étaient semblables et les valeurs de ces dernières étaient généralement semblables pour les principaux métaux (Zn, Cu, Cd). On notait des signes de faible contamination des échantillons de métaux dissous.

Chimie des sédiments

Les concentrations de métaux totaux dans les sédiments étaient plus élevées dans la zone voisine, plus faibles dans la zone éloignée, et les valeurs les plus faibles étaient observées dans la zone de référence (Zn, Cu, Cd, Pb, As). Les concentrations de tous ces métaux dépassaient les limites de l'évaluation intérimaire canadienne de la qualité des sédiments (Canadian Interim Sediment Quality Assessment Values), surtout dans la zone voisine où les concentrations étaient supérieures aux teneurs à effets probables. Les concentrations partielles de métaux suivaient un profil semblable de distribution spatiale, même si, de façon générale, la fraction des concentrations partielles de métaux ne représentait qu'une partie relativement petite des concentrations totales.

Les rapports molaires des concentrations des sulfures volatils en milieu acide et de celles des métaux extractibles simultanément dans les sédiments présentaient de fortes variations à l'intérieur des zones, et leurs valeurs étaient généralement plus élevées dans les stations de la zone voisine, plus faibles dans celles de la zone éloignée, et les valeurs les plus faibles étaient observées dans la zone de référence. Les résultats indiquaient que les sédiments de la zone voisine et, dans une moindre mesure, ceux de la zone éloignée peuvent être toxiques pour les organismes qui les habitent.

Toxicité des sédiments

Les sédiments de la zone voisine, de la zone éloignée et de la zone de référence du lac présentaient divers degrés de toxicité pour *Chironomus, Hyalella* et *Tubifex.* Les sédiments de la zone voisine étaient toxiques pour les deux premières espèces (survie et croissance). On observait chez *Hyalella* une réponse du taux de survie et de croissance dans les sédiments de la zone éloignée par rapport à la réponse pour la zone de référence, mais on n'observait aucune réponse du taux de survie de *Tubifex*, et les réponses des fonctions reproductives aux effets des sédiments de la zone voisine et de la zone éloignée étaient faibles.

Macroinvertébrés benthiques

Les macroinvertébrés benthiques ne répondaient pas à l'exposition aux sédiments enrichis en métaux pour ce qui est des densités des organismes, du nombre de taxons ou de l'abondance des chironomidés. Toutefois, les harpactacoïdes et *Pisidium* étaient pratiquement absents dans la zone d'exposition (lac Buttle), mais ils étaient plutôt communs dans la zone de référence (lac Brewster).

Dans le ruisseau Myra, on observait des différences relativement petites entre les valeurs de benthos de la zone d'exposition et celles de la zone de référence; on notait des valeurs légèrement réduites de densités d'organismes, de nombres de taxons et de nombres de taxons sensibles **E**phemeroptera, **P**lecoptera et **T**richoptera (EPT) dans les stations exposées.

Toxicité des effluents

Les effluents de Myra Falls étaient non toxiques pour la tête-de-boule. Les valeurs de toxicité chronique (CI_{25}) étaient semblables pour *Ceriodaphnia, Selenastrum* et *Lemna*, c'est-à-dire que la reproduction (*Ceriodaphnia*) ou la croissance (autres espèces) étaient inhibées de 25 % (valeur moyenne) par une exposition à des concentrations d'effluents de 35 à 45 %.

Vérification des hypothèses

Les résultats des vérifications des hypothèses sont résumés au tableau 5.2; ils indiquent qu'il y a des réponses biologiques mesurables à Myra Falls et que des contaminants (métaux) semblent être la cause de ces réponses biologiques.

Évaluation des techniques

Dans l'ensemble, la plupart des outils de surveillance évalués à Myra Falls étaient efficaces pour la démonstration de l'existence d'un effet dû aux activités minières, à l'exception du test de toxicité chronique pour la tête-de-boule et de l'analyse des rapports entre les concentrations des sulfures volatils en milieu acide et celles des métaux extractibles simultanément. Certains des outils jugés efficaces l'étaient légèrement plus que d'autres comme prédicteurs de la réponse biologique. On présente au tableau 6.2 un résumé de l'efficacité des divers outils de surveillance testés à Myra Falls et, au tableau 6.3, une comparaison de l'efficacité d'outils semblables utilisés pour mesurer des effets aquatiques à Myra Falls.

Un document distinct, « Summary and Cost-Effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Evaluation Program », présente les conclusions sur le rapport coût-efficacité de ces outils, qui sont basées sur les résultats obtenus pour les quatre sites miniers étudiés en 1997.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

Table No.

LIST OF FIGURES

Figure No.

ANNEX 1: Detailed Field and Laboratory Procedures and Results
(available upon request from CANMET, Natural Resources Canada)

- Effluent Chemistry Reports : Myra Falls, Placer Dome, Heath Steele
- Effluent Toxicity Test Reports : Myra Falls, Placer Dome, Heath Steele
- Water Sample Collection Methods Applied in the 1997 AETE Field Evaluations
- Sediment Sample Collection Methods Used for the 1997 AETE Field Evaluations
- Benthic Sampling Methods for the 1997 AETE Field Evaluations
- Fish Sample Collection Methods for the 1997 AETE Field Evaluations
- Procedure for Partial Extraction of Oxic Sediments
- Procedure for Preparation of Fish Tissues for Metallothionein Analyses
- Mercury Saturation Assay for Metallothionein
- Water Chemistry Reports : Myra Falls, Placer Dome, Heath Steele, Mattabi
- AVS/SEM Sediment Chemistry Reports : Myra Falls, Placer Dome, Heath Steele
- Partial Extraction Sediment Chemistry Reports : Myra Falls, Placer Dome, Heath Steele
- Total Metals Sediment Chemistry Reports : Myra Falls, Placer Dome, Heath Steele
- Placer Dome Fish Tissue Chemistry
- Heath Steele Detailed Periphyton Results – Species and Biomass Chemistry Data
- Benthic Study Field Data Sheets – Placer Dome, Heath Steele, Mattabi
- Stream Habitat Assessment Data Sheets – Heath Steele, Mattabi

ANNEX 2 : Additional Tool Evaluations
(available upon request from CANMET, Natural Resources Canada)

1.0 INTRODUCTION

The Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN), initiated in 1993, evaluated the effectiveness of Canada's *Metal Mining Liquid Effluent Regulations* (MMLER). One of the key recommendations of the 1996 AQUAMIN Final Report was that a revised MMLER include a requirement that metal mines conduct Environmental Effects Monitoring (EEM), to evaluate the effects of mining activity on the aquatic environments, including fish, fish habitat and the use of fisheries resources.

In parallel, the Canada Centre for Mineral and Energy Technology (CANMET) is coordinating a cooperative government-industry program, the Aquatic Effects Technology Evaluation (AETE) program, to review and evaluate technologies for the assessment of mining-related impacts in the aquatic environment. The intention of the AETE program is to evaluate and identify cost-effective technologies to meet environmental monitoring requirements at mines in Canada. The program is focused on evaluation of environmental monitoring tools that may be used for a national mining EEM program, baseline assessments or general impact studies.

The three principal components of the AETE program are lethal and sublethal toxicity testing of water/effluents and sediments, biological monitoring in receiving waters, and water and sediment chemistry assessments. The program includes both literature-based technical evaluations and comparative field programs at candidate sites. The AETE program is presently at the stage of evaluating selected monitoring methods at four case study sites across Canada.

An AETE Pilot Field Study was carried out in the Val d'Or region of Quebec in 1995 to evaluate a large number of environmental monitoring methods and to reduce the list of monitoring technologies for further evaluation at a cross-section of mine sites across Canada (BEAK, 1996). In 1996, a field evaluation program was initiated and involved preliminary sampling at seven candidate mine sites with the objective of identifying a short-list of mines that had suitable conditions for further detailed monitoring and testing of hypotheses related to the AETE program. Preliminary study designs were developed for four sites that were deemed to be most suitable for hypotheses testing in 1997 (EVS *et al.*, 1997). The sites selected were Heath Steele, New Brunswick; Lupin, Northwest Territories; Dome Mine, Ontario; and Westmin Resources (now Boliden-Westmin), British Columbia. Lupin was subsequently dropped based on a 1997 reconnaissance survey and replaced with the Mattabi

Mines Ltd. site in Ontario (BEAK and Golder, 1998a). The following report documents the results of the 1997 Field Evaluation at the Westmin Resources (Boliden-Westmin) Myra Falls Operation in British Columbia.

The 1996 Field Evaluation Program constituted Phase I of the Field Evaluation Program. The 1997 program consists of Phases II and III of the Program. Phase II includes the review of necessary background information, finalization of a study design and implementation of the field studies. Phase III includes the compilation, interpretation and reporting of results.

1.1 Study Objectives

The overall goal of the AETE Program is to identify cost-effective methods and technologies that are suitable for assessing aquatic environmental effects caused by mining activity. An effect is defined as "a measurable difference in an environmental variable (chemical, physical or biological) between a point downstream (or exposed to mining) in the receiving environment and an adequate reference point (either spatial or temporal)". Based on this definition, the AETE Technical Committee developed a series of hypotheses to be tested under field conditions at a number of mine sites in Canada. The Committee agreed that specific hypotheses should be articulated in order to clarify the purpose of the program elements. For the formulation of the hypotheses, the definition of an effect was refined by the AETE Committee to distinguish between effects or responses as measured in biological variables as opposed to effects reflected in physical or chemical changes.

The questions used in developing the hypotheses to be tested in the 1997 field evaluation program were:

1. Are contaminants getting into the system (and to what degree, and in which compartments)? This question relates to the presence of elevated concentrations of metals in environmental media (e.g., water, sediments), and requires an understanding of metal dispersal mechanisms, chemical reactions in sediment and water, and aquatic habitat features which influence exposure of biological communities.

2. Are contaminants bioavailable? This question relates to the presence of metals in biota or to indicators of bioaccumulation such as the induction of

metallothionein in fish. Only if contaminants are bioavailable can a biological effect from chemical contaminants occur.

3. Is there a measurable response? Biological responses may occur only if contaminants are entering the environment and occur in bioavailable forms. These responses may occur at various levels of biological organization, including sub-organism levels (e.g., histopathological effects), at the organism level (e.g., as measured in toxicity testing), or at population and community levels (as measured in resident benthic invertebrate and fish communities).

4. Are contaminants causing the responses? This question is difficult to measure in field studies directly, as cause-effect mechanisms are difficult to assess under variable conditions prevailing in nature. However, correlations between measures of exposure, chemical bioavailability and response may be used to develop evidence useful in evaluating this question.

The AETE Technical Committee developed a study framework, using the above questions and the three components (water and sediment monitoring, biological monitoring in receiving waters and toxicity testing). The following eight areas of work were identified to finalize the work plan, develop the hypotheses, prioritize issues and identify field work requirements:

1. Chemical presence;
2. The overlap between communities and chemistry testing to determine whether biological responses are related to a chemical presence (bioavailability of contaminants);
3. Biological response in the laboratory;
4. Biological response in the field;
5. Chemical characteristics of the water and sediments used to predict biological responses in the field (contaminants causing a response);
6. The overlap between biological communities responses and bioassay responses to evaluate whether wild community changes are predicted by bioassay responses;
7. The overlap between chemistry and bioassay responses to evaluate whether chemicals are responsible for bioassay responses; and

8. The overlap between the chemical, the exposure and the effects in the laboratory and the effects in the field.

The core objective, however, is to **test the 13 hypotheses, developed by the AETE Committee, at as many of the four selected mine sites as possible (Table 1.1)** The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer the four general questions (above) about mine effects.

These 13 hypotheses can be categorized as follows:

- ***Sediment Monitoring***: evaluation of sediment toxicity testing tools (test types) as to their relative ability to detect linkages between mine exposure and sediment toxicity (H1);

- ***Biological Monitoring (in Fish)***: evaluation of tissue biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and tissue contamination (H2 to H4); and evaluation of population/community biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and ecological response (H5 to H8); and

- ***Integration of Tools***: evaluation of various monitoring tools as to their relative ability to detect relationships between specific measures of mine exposure and specific biological response measures, or between sediment toxicity and benthic community response measures (H9 to H12); and evaluation of effluent toxicity testing tools (test types) as to their ability to detect relationships between effluent toxicity and population/community response measures (H13).

Due to the natural characteristics of the site, only four of these 13 hypotheses (H1, H6, H10 and H11) were testable at Myra Falls. Hypotheses H9 and H13 were evaluated in a qualitative manner because the site characteristics (i.e., no water chemistry gradient in Myra Creek) did not support a statistical analysis of the data for these two hypotheses. Hypothesis H6, which is intended to examine fish community responses to exposure, is tested at the Myra Falls Operation using benthic invertebrate indicators in lake and stream areas. In addition, it was desired to evaluate an overall "sediment quality triad"

TABLE 1.1: HYPOTHESES TESTED IN 1997. AETE FIELD PROGRAM
(Hypotheses in bold print were tested at Myra Falls)

Sediment Monitoring

H1. Sediment Toxicity:
H: ***The strength of the relationship between sediment toxicity responses and any exposure indicator is not influenced by the use of different sediment toxicity tests or combinations of toxicity tests.***

Biological Monitoring - Fish

H2. Metals in Fish Tissues (bioavailability of metals):
H: *There is no difference in metal concentrations observed in fish liver, kidney, gills, muscle or viscera.*

H3. Metallothionein in Fish Tissues:
H: *There is no difference in metallothionein concentration observed in liver, kidney, gills, viscera*

H4. Metal vs. Metallothionein in Fish Tissues:
H: *The choice of metallothionein concentration vs. metal concentrations in fish tissues does not influence the ability to detect environmental exposure of fish to metals.*

H5. Fish - CPUE:
H: *There is no environmental effect in observed CPUE (catch per unit effort) of fish.*

H6. Fish (or Benthic) - Community:
H: ***There is no environmental effect in observed fish (or benthic) community structure.***

H7: Fish - Growth:
H: *There is no environmental effect in observed fish growth.*

H8. Fish - Organ/Fish Size:
H: *There is no environmental effect in observed organ size (or fish size, etc.).*

Integration of Tools

H9.* Relationship between Water Quality and Biological Components:
H: ***The strength of the relationship between biological variables and metal chemistry in water is not influenced by the choice of total vs. dissolved analysis of metals concentration.***

H10. Relationship Between Sediment Chemistry and Biological Responses:
H: ***The strength of the relationship between biological variables and sediment characteristics is not influenced by the analysis of total metals in sediments vs. either metals associated with iron and manganese oxyhydroxides or with acid volatile sulphides.***

H11. Relationship Between Sediment Toxicity and Benthic Invertebrates:
H: ***The strength of the relationship between sediment toxicity responses and in situ benthic macroinvertebrate community characteristics is not influenced by the use of different sediment toxicity tests, or combinations of toxicity tests.***

H12. Metals or Metallothionein vs. Chemistry (receiving water and sediment):
H: *The strength of the relationship between the concentration of metals in the environment (water and sediment chemistry) and metal concentration in fish tissues is not different from the relationship between metal concentration in the environment and metallothionein concentration in fish tissues.*

H13.* Chronic Toxicity - Linkage with Fish and Benthos Monitoring Results:
H: ***The suite of sublethal toxicity tests cannot predict environmental effects to resident fish performance indicators or benthic macroinvertebrate community structure.***

* H9 and H13 were addressed qualitatively.

hypothesis, that addresses whether mine-related contaminants appear to be causing biological responses.

1.2 Site Description

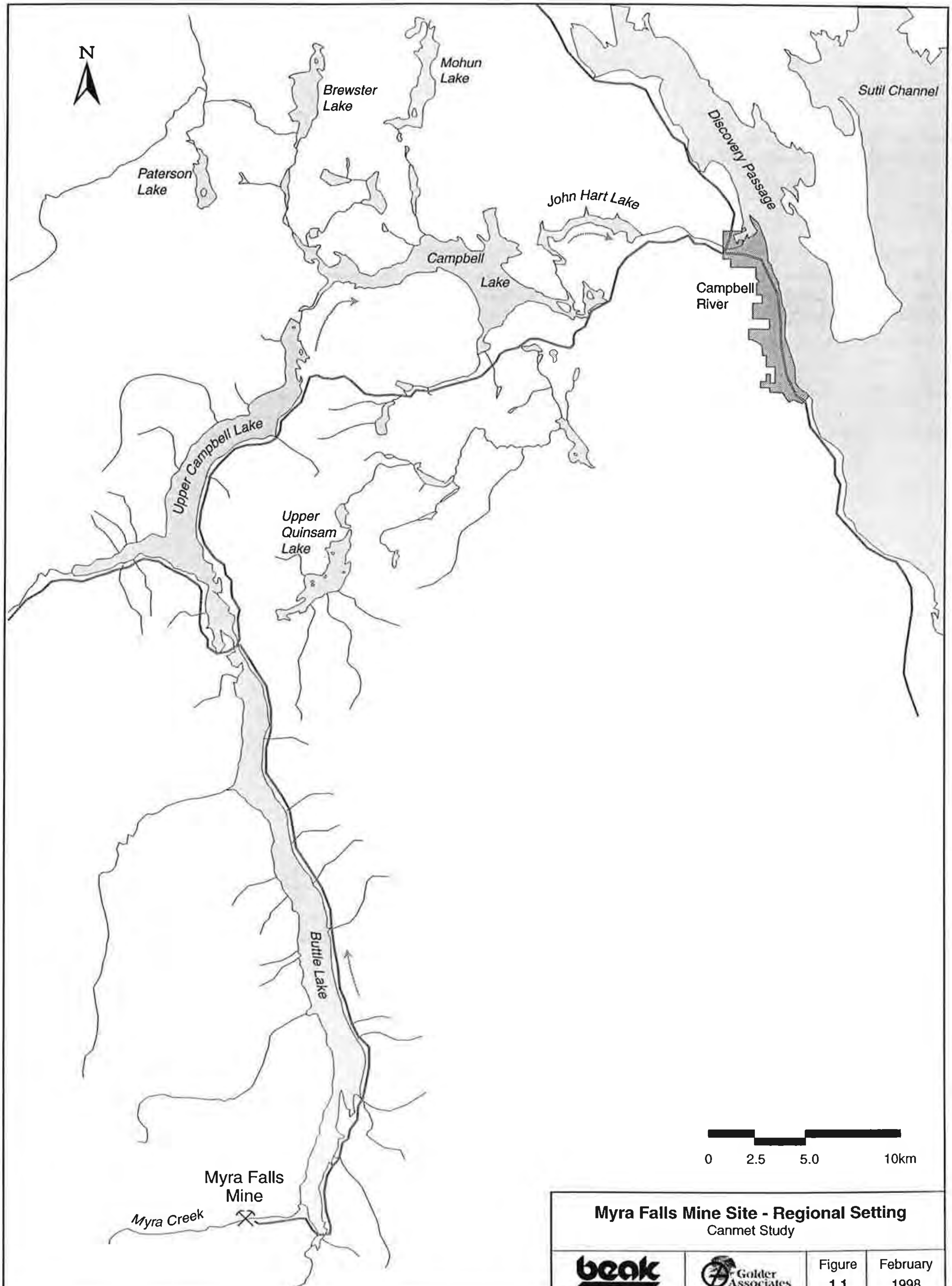
The Myra Falls Operations of Westmin Resources (now Boliden-Westmin Myra Falls Operations) produces base metal concentrates (zinc, copper, lead, silver and gold), and is located in central Vancouver Island, within Strathcona Provincial Park. The operations started in 1966 and are situated in the Myra Creek valley. Myra Creek receives discharges from the operations and drains into Buttle Lake, a deep, oligotrophic system (Figure 1.1). Buttle Lake discharges northward and eastward through a series of reservoirs into the Campbell River.

From the mid-1960s to mid-1980s, the mine discharged tailings into Buttle Lake. In response to concerns over potential impacts on aquatic resources, the mine abandoned deep lake disposal in the mid-1980s in favour of subaerial disposal within the Myra Creek watershed.

Metal-contaminated water from the Myra Falls Operations is collected, treated with lime and discharged to Myra Creek. Some metal loadings are also produced from other sources in the vicinity of Myra Falls operations, as noted by site personnel (Gavin Dirom, Westmin Resources, pers comm., 1997). This is reflected in the water chemistry results of this study, whereby zinc concentrations at the near-field sites were substantially higher than those predicted using the effluent and upstream receiving water concentrations.

Myra Creek, an oligotrophic stream (supported by the water quality data herein), flows eastward from the mine and into the southern portion of Buttle Lake, approximately 2 km downstream. Myra Falls, a waterfall near the mouth of the creek, presents a physical barrier to the movement of aquatic biota upstream from the lake. Buttle Lake is 35 km in length with a mean depth of 45 m.

Aquatic habitats in the study area include fast-flowing and erosional conditions in Myra Creek, and deep, soft-bottom depositional conditions in Buttle Lake.



Myra Falls Mine Site - Regional Setting
Canmet Study

Figure **1.1** February 1998

2.0 STUDY DESIGN

2.1 Adjustments to Preliminary Study Design

EVS *et al.* (1997) developed a preliminary study design for sampling at Myra Falls, based on the data from the 1996 field evaluation. However, refinements were made to this design based on additional (1997) reconnaissance data relating to aquatic biota and metal concentration gradients downstream of the mine.

The reconnaissance survey was carried out during the week of 09 June 1997 to evaluate the feasibility of testing sediment and benthic invertebrate related hypotheses in Buttle Lake, and to evaluate the feasibility of collecting fish and benthos from Myra Creek rather than Buttle Lake for testing of fish and benthic-related hypotheses. The survey showed a gradient in sediment zinc concentrations in Buttle Lake, but little gradient in cadmium, copper and lead (Appendix 1). Although the reconnaissance data did not delimit the extent of metal contamination in Buttle Lake sediments, areas further away from Myra Creek (e.g., the northern end of Buttle Lake 35 km downstream) were expected to have lower contaminant levels. There was a difference in water chemistry in Myra Creek downstream of the mine site compared with upstream, but no gradient was observed throughout its length downstream to Buttle Lake.

Based on the reconnaissance survey, the following key findings influenced changes to the study design for Myra Falls:

- Electrofishing of Myra Creek upstream and downstream of the mine in June 1997 showed fish to be extremely low in abundance. None were captured and only two were seen. This may be attributed to the zoogeographic isolation of the watershed by Myra Falls. Therefore, fish sampling in Myra Creek to test fish-related hypotheses was no longer considered viable.

- Sampling showed that benthic invertebrates were present in reasonable abundances and apparent diversities in the deep, profundal sediments of Buttle Lake (sampled up to 60 m water depth) where tailings had historically been deposited. The sediment chemistry gradient showed only small spatial trends in the near-field area, but sediments showed elevated zinc concentrations.

Therefore, a step-wise reduction in sediment metal level was expected at the north end of Buttle Lake due to separation by distance and depth (up to 127 m) from south Buttle Lake and to the fact that tailings deposition had occurred in the south end only. Therefore, sediments were analyzed for benthic invertebrates, toxicity and chemistry in south Buttle Lake (near-field), north Buttle Lake (far-field) and a reference lake (Brewster Lake, which is of comparable depth to areas sampled in Buttle Lake).

- Fish sampling, originally proposed by EVS *et al.* (1997) was omitted from the Buttle Lake sampling program, because lake metal concentrations have decreased since the metallothionein study undertaken by Roch *et al.* (1982). Also, there was a general lack of confidence that the fish community and CPUE-related tools could be effectively used to compare between reference and exposure lakes, owing to substantial influence of zoogeographic and habitat differences between Buttle Lake (a deep, artificial reservoir) and the proposed reference lake (Upper Quinsam Lake). In addition, B.C. Ministry biologists indicated that there were no rainbow trout in the proposed reference lake and recommended Brewster Lake as an alternative reference lake. Brewster Lake was also an appropriate reference lake for the benthic survey because it offered similar depth ranges to those in Buttle Lake.

- Zooplankton sampling was not carried out for testing of H9, as suggested by EVS *et al.* (1997), owing to an expected poor gradient in water chemistry in Buttle Lake and to the inherent spatial and temporal variability in zooplankton communities. The absence of an obvious spatial gradient in water chemistry with distance from the mouth of Myra Creek was confirmed by conductivity measurement in June 1997, and was evident based on water chemistry monitoring information provided by the mine.

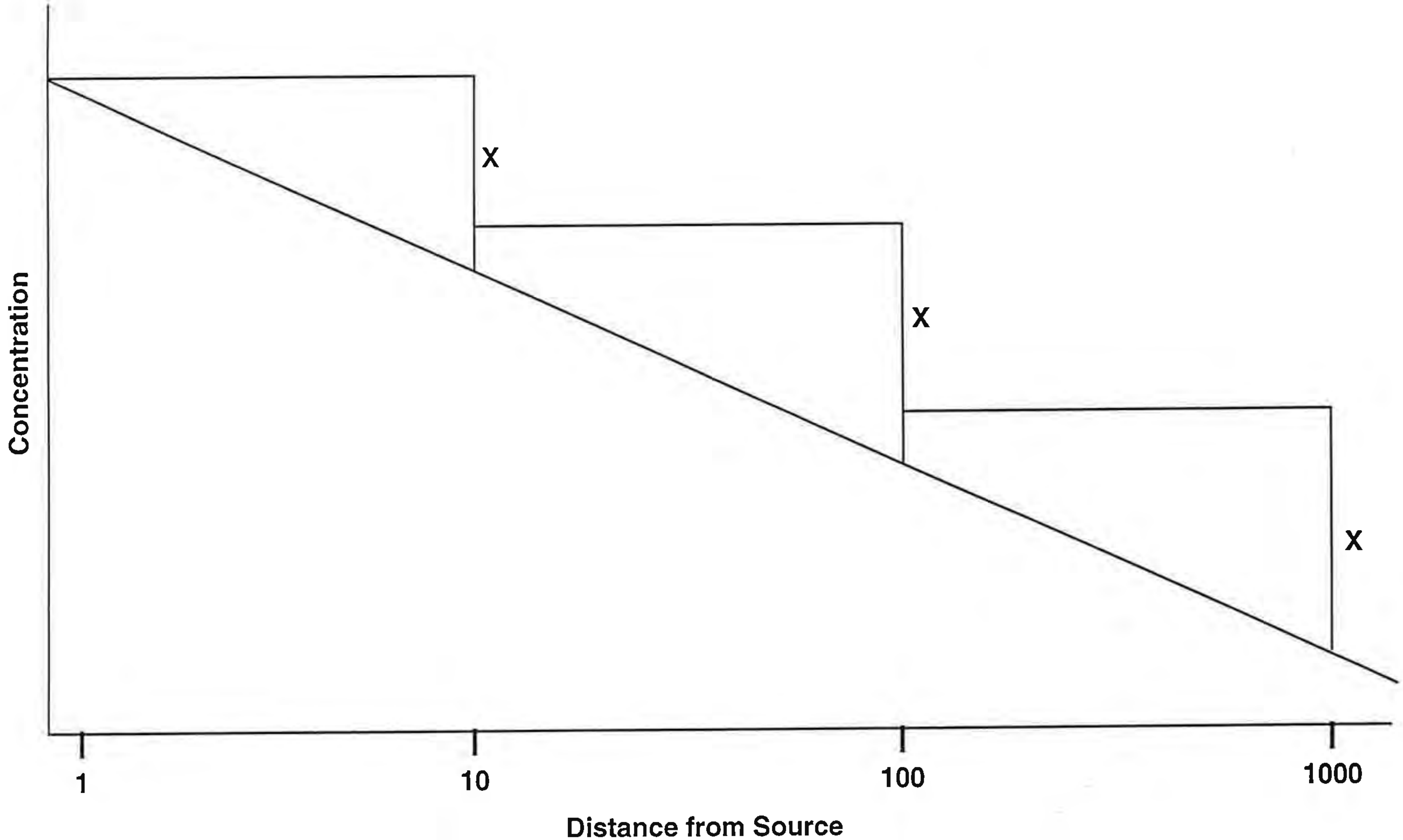
- H13 was tested qualitatively by comparison of effluent chronic toxicity with Myra Creek benthic results. Previous chronic testing by EVS *et al.* (1997) showed that chronic thresholds were high (i.e., little or no dilution is needed to eliminate effects). Testing of H13 in Buttle Lake where dilution is substantial was therefore considered inappropriate. In addition, a significant component of the zinc loading to Myra Creek originates from sources other than the treated effluent which was tested for toxicity.

2.2 Final Study Design

2.2.1 General Considerations

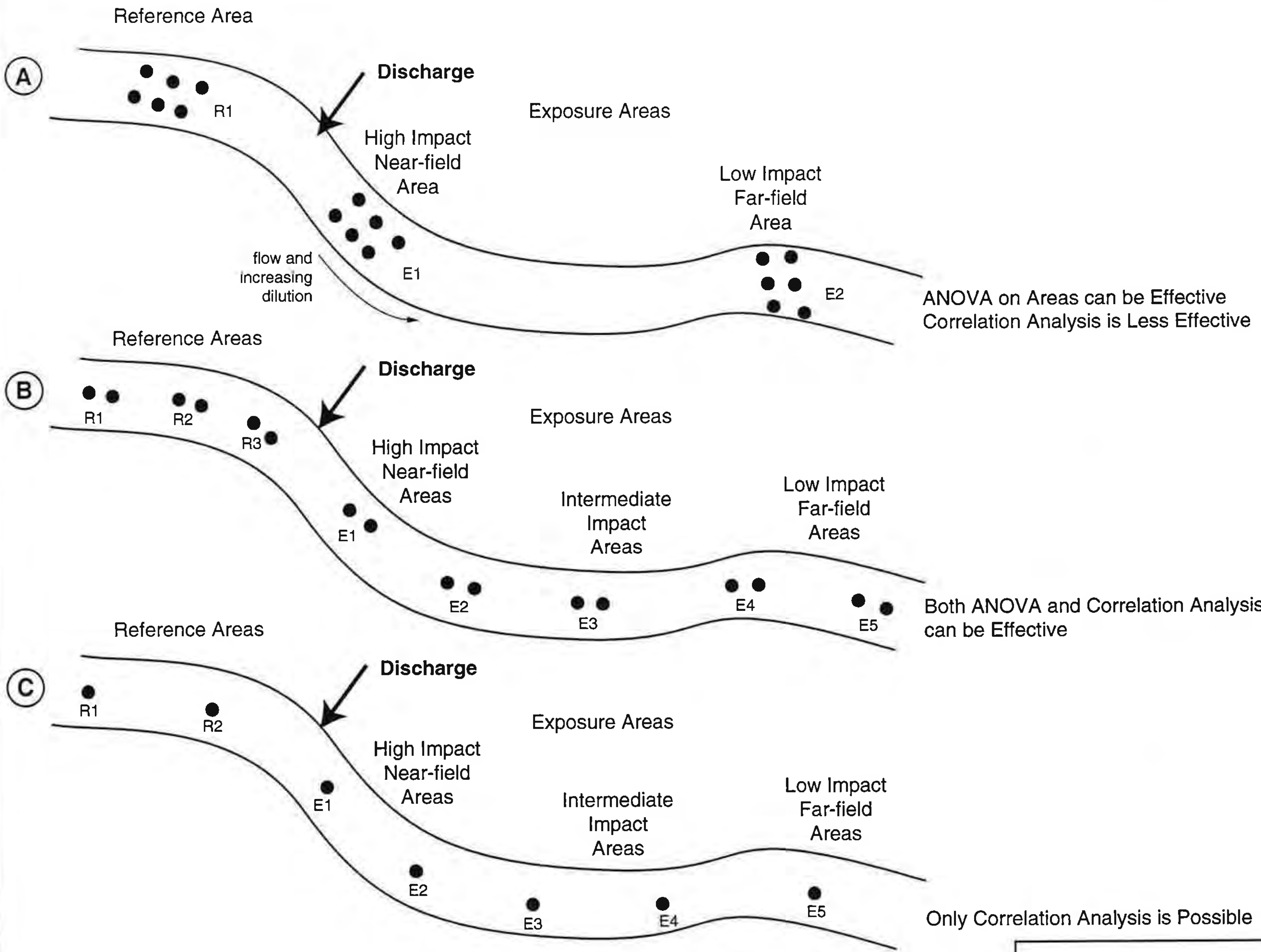
In general, sampling is carried out in relation to a point source discharge in order to permit testing of hypotheses about the environmental effect of the discharge. Sampling is carried out both above and below the source (Control versus Exposed). To the extent possible, it is desirable to space the "below discharge" samples at exponentially increasing distances, because most dilution/mixing models are exponential decay models. That is, a contaminant will decrease in concentration by a given amount over each order of magnitude increase in distance from the discharge (see Figure 2.1). When monitoring mine discharges, the nature of the receiving environment will often cause this ideal to be impossible to achieve, especially where tributary streams produce a stepwise dilution of effluent, or when dilution occurs rapidly (e.g., a stream discharging into a large lake). This latter condition prevails at the Myra Falls Operations.

There are many possible field study designs for monitoring of mining discharges and testing of the hypotheses, which can be put into three basic categories (Figure 2.2, Types A, B, C). The difference between the first two (Type A versus Type B or C) is driven by site differences (e.g., stepwise (Type A) versus more continuous dilution patterns (Types B and C)), whereas the difference between the Type B and Type C is driven by the biota being sampled. For example, benthos because of their sessile nature, and some forage fish because of their limited mobility, allow for replicate sampling in a small area (Type B) with the primary design constraints being hydrology and habitat. For larger more mobile fish, sampling would be carried out over a larger area to ensure the groups of fish are not mixing and are distinct from one another, possibly necessitating a Type C design. Alternatively, a Type A design might be used for large fish, using individual fish rather than stations as replicates.



Idealized Effluent Dilution Model Downstream of a Mine Discharge

beak international incorporated	Figure 2.1	February 1997



Representative Sampling Designs Downstream of Effluent Discharges (dots represent sampling stations)

beak international incorporated	Figure 2.2	May 1998

The ideal situation for testing hypotheses for the 1997 field evaluation is a Type B study design which is a combination of easy-to-sample biota and a site which can be sampled with a gradient design approximating that described above. This provides for:

- a gradient design permitting regression/correlation analysis of the impact pattern along the stream below the discharge, and of possible cause-effect relationships between chemical and biological variables; and
- replication at locations so that testing in an Analysis of Variance (ANOVA) design is possible.

Due to the natural site characteristics at Myra Falls, the Type B study design could not be implemented.

The other two types of study design (Types A and C) sacrifice either one or the other of the above two attributes (i.e., a gradient design with replication at each location). For Type A, the nature of the site precludes a gradient design (e.g., Myra Falls). Therefore, replicate samples are taken at an "above"="Control" location, and at a "near field"="High Impact" and at a "far field"="Low Impact" location. This does not allow one to model the pattern of impact below the discharge, but an ANOVA for testing impact-related hypotheses is easily done.

For a Type C study design (i.e., gradient design with no replication), one can model the pattern of impact below the discharge but the only possible hypothesis testing is that associated with simple regression analysis. However, there still needs to be a gradient in contaminant levels for this type of design. This type of study design was not used at any of the mine sites studied in the 1997 field evaluation program.

Finally, it is necessary to select an appropriate sampling effort and (apart from the above "basic types of design" considerations) to allocate the effort appropriately to above versus below discharge areas, to locations within areas, and to replicates within locations. For the AETE program, it was determined by the AETE Technical Committee that a total sampling effort per mine site of 20 to 25 field samples was a reasonable trade-off between feasibility and cost and statistical power and robustness (EVS *et al.,* 1997). The following is based on that total effort allocated to Myra Falls.

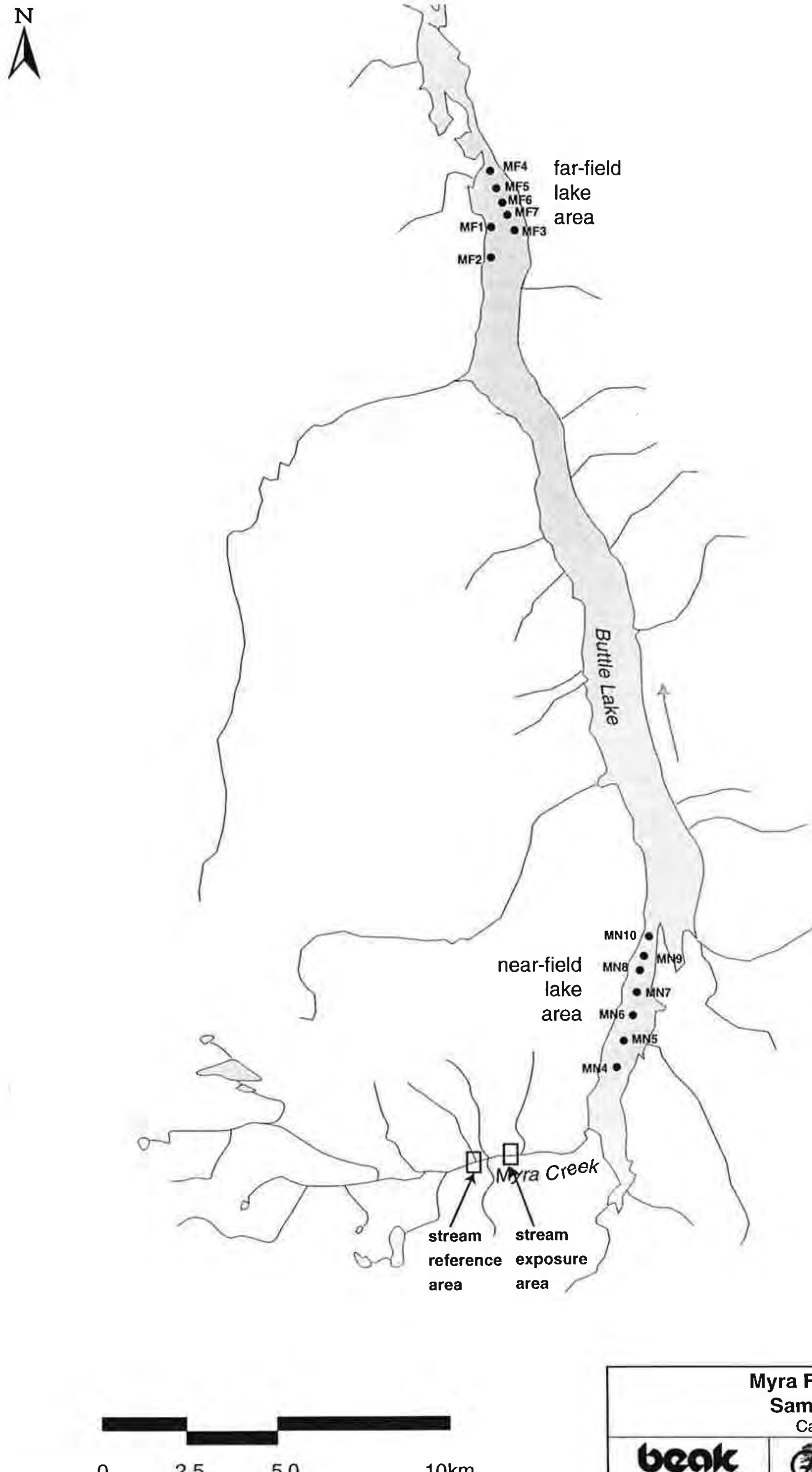
2.2.2 Design at Myra Falls

Sampling Areas

The study design at Myra Falls was generally of the first type in Figure 2.2 (Type A). This was based on the existence of a near-field area in Buttle Lake, directly affected by past tailings disposal practices, as well as, ongoing effluent discharges, and a far-field area well beyond the tailings deposition area and where the effluent is highly diluted (Figures 2.3 and 2.4). The reference area was in nearby Brewster Lake because it offered comparable water depths and bottom substrates to those in Buttle Lake and because Myra Creek enters into the lower south end of Buttle Lake preventing the selection of an upstream reference area in the lake. There is almost 35 kilometres between the near field and far field in Buttle Lake where lake depth is extreme (up to 127 m) making benthic habitat conditions different than the near field or the far field, and preventing effective establishment of a gradient design in the form of Type B in Figure 2.2. The sampling design in Buttle and Brewster Lakes allows for testing of sediment-related hypotheses.

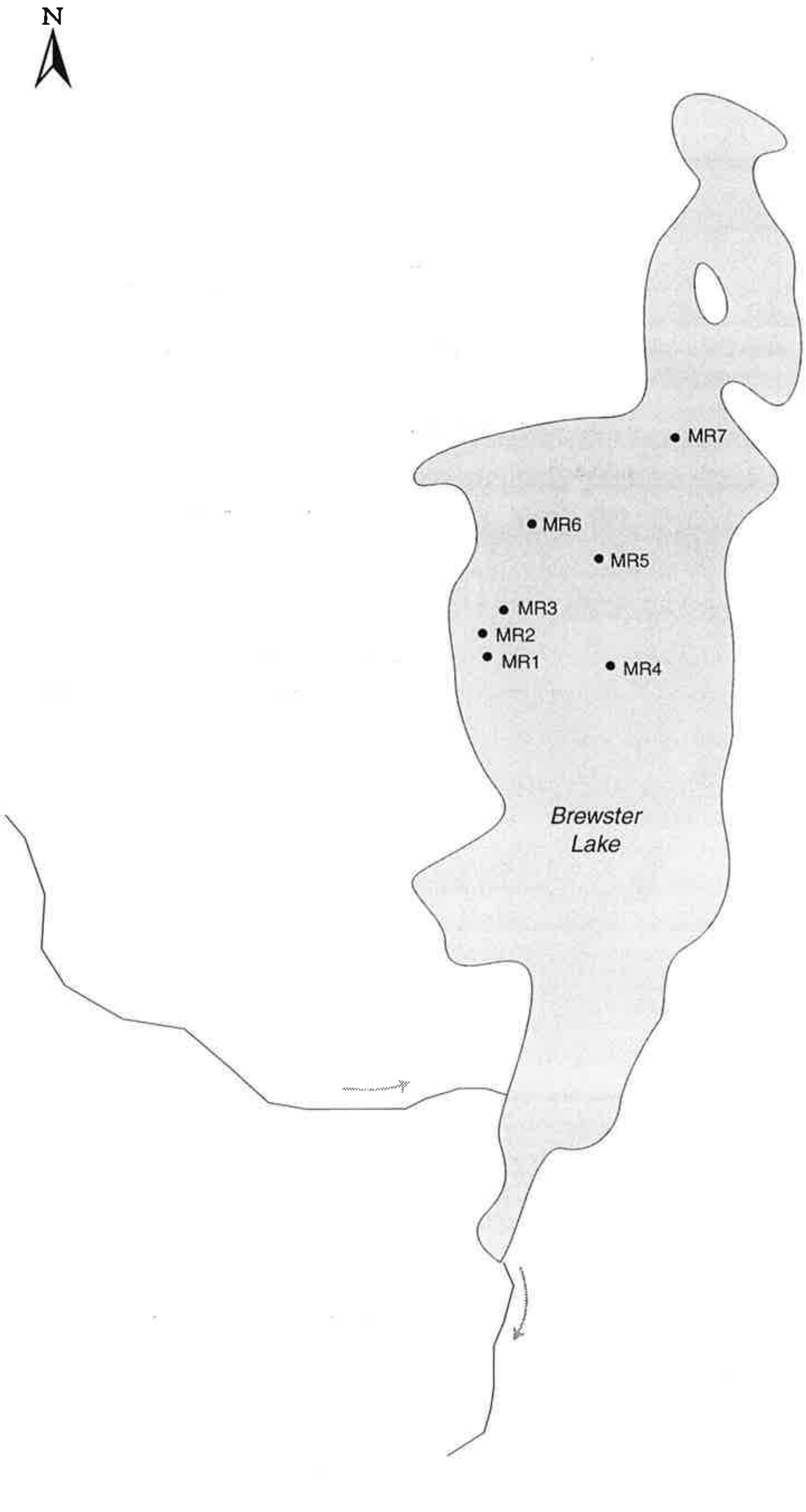
The study design for Buttle Lake allowed for the collection of sediment for chemical and toxicity testing, as well as for benthic invertebrate community characterization, at each of seven stations within the near-field, far-field and reference areas (Figures 2.3 and 2.4). All stations were located at water depths between approximately 30 to 40 m. For benthos, the sample from each station was a composite of five petite-Ponar grabs, whereas for sediment chemistry and toxicity each sample was taken from a composite of the surface 3 cm from approximately 15 standard Ponar grabs.

The exposure gradient in Myra Creek is not clearly defined and metal levels change little with distance in the creek downstream of the mine, once the effluent and seepage from other sources are fully mixed with the creek water. Exposure and reference sites in Myra Creek included a downstream and an upstream area (Control-Impact or CI Design) relative to the mine effluent discharge and seepage sources. This design represented a simplification of design Type A in Figure 2.2 (reference and near-field area only). Benthic invertebrates were collected at ten stations located in each area, and three water samples were collected in each area. Each sample for benthos was a composite of five T-sample grabs (total area 0.5 m^2). These data are used to address linkages between benthos and water chemistry in reference and exposure reaches in Myra Creek. Multiple exposure reaches were not sampled because there was no water chemistry gradient in Myra Creek downstream of the mine site.



Myra Falls Mine Site
Sampling Areas
Canmet Study

beak	Golder Associates	Figure **2.3**	February 1998



Myra Falls Mine Site - Reference Stations in Brewster Lake
Canmet Study

beak	Golder Associates	Figure 2.4	February 1998

2.2.3 Statistical Power

The statistical power of the study design was evaluated using the Borenstein and Cohen (1988) computer code for power analysis. In Myra Creek for Hypothesis H6, the total sampling effort of 20 sampling stations equally distributed among two groups (reference and exposure areas) is sufficient to expect that an effect size (average difference between groups) of two within-group standard deviations could be detected with a power of 0.8 or better (i.e., chance of false-negative conclusion (beta) less than 0.2) using a significance criterion based on a chance of false-positive conclusion (alpha) less than 0.05. In Buttle Lake and Brewster Lake, the total sampling effort of 21 sampling stations (for Hypotheses H1 and H6) equally distributed among three groups (reference, near-field and far-field) is sufficient to expect that an effect size of two within-group standard deviations could be detected with a power of 0.8 or better using an alpha less than 0.05. The absolute difference indicated by the one or two standard deviations will vary from one monitoring parameter (effect measure) to another.

For H10 and H11, with a total of 21 stations, it should be possible to detect strong chemistry-biology-toxicity correlations (those that exceed $r = 0.7$; power = 0.8).

3.0 FIELD AND LABORATORY METHODS

3.1 Sampling Time and Crew

The field survey was conducted at Myra Falls on Vancouver Island between 02 to 14 September 1997. The field crew consisted of Jay Dickison, who was also a crew member for the Heath Steele and Dome Mine sites (Beak International Incorporated), Don Sinclair (contractor for Golder Associates) who also participated in the field component of the Mattabi site, Gail Wada (Golder Associates) and Bettina Sander (Golder Associates) who was the project manager.

Benthic invertebrate samples, stream habitat characteristics, stream discharge and water samples were collected from both a reference and near-field exposure area in Myra Creek. Sediment, water and benthic invertebrate samples were collected from near-field and far-field areas in Buttle Lake and from a reference area in Brewster Lake.

3.2 Sampling Effort and Station Characterization

Myra Creek

Samples were collected from an area immediately downstream of the mine effluent discharge where conductivity measurements indicated that the effluent was completely mixed with the receiving water and from an area upstream of the mine effluent discharge in Myra Creek (refer to Figure 2.3). The downstream exposure area was located at an unvegetated gravel bar identified during the June 1997 site reconnaissance survey (Appendix 1). General habitat characteristics of this area include pool-riffle habitat sequence, gravel-cobble substrate, low gradient and poor to fair in-stream cover.

The criteria for selecting an upstream reference area in Myra Creek were based on it having similar habitat characteristics to those found in the exposure area and having minimal mine influence (e.g., upstream of effluent discharge, upstream of any contaminated groundwater or tailings seepage, upstream of discharges from creeks/tributaries to Myra Creek which flow through the mine site potentially transporting mine-related contaminants). The section of Myra Creek most suitable as a reference area was located just upstream of the mine property.

Within each of the exposure and reference areas, ten sampling stations with similar habitat characteristics were selected for collection of benthos. Habitat conditions and station coordinates, measured by Global Positioning System, were recorded on data forms (Appendix 3). Habitat information included stream order, data on water temperature, conductivity, pH, substrate conditions, pool/riffle ratio, aquatic plant coverage, in-stream and riparian cover, water depth and general flow conditions (Appendix 3). Because the stations within each area were in close proximity to each other and their location was in a flowing environment, water samples were collected at three of the stations in each area (one station located at the upper, middle and lower end of the area).

Buttle and Brewster Lakes

Sampling sites in Buttle and Brewster lakes were selected based on similar depths and sediment characteristics. A depth sounder was used to select locations of appropriate depths (i.e., 30 to 42 m), and areas of similar benthic habitat were confirmed by visual observations of sediment grain size (i.e., fines) and colour (i.e., brown to dark brown). Based on these observations, the near-field area was located at the southern end of Buttle Lake, the far-field area at the northern end of Buttle Lake and the reference area in Brewster Lake (refer to Figures 2.3 and 2.4). Seven stations were established in each of these areas and sampled for benthic invertebrates, sediment and water. Water samples were collected 0.5 m above the sediments, although at one station in the near-field a surface sample was also collected to determine if there was stratification in water contaminant levels.

3.3 Effluent Chemistry and Toxicity

Toxicity testing was conducted on effluent samples collected from the mine discharge. Sixty litres of effluent were collected by Westmin Resources personnel on 02 July, 13 August, 30 September and 01 December 1997 and shipped to Beak International Incorporated. The first effluent sample was collected on 02 July 1997, but re-sampling was required on 13 August 1997 due to courier problems getting the sample to the Saskatchewan Research Council for the duckweed testing. Therefore, there are four measurements for fathead minnow, *Ceriodaphnia* and *Selenastrum*, but only three for duckweed.

Toxicity tests conducted on each sample included:

- the *Ceriodaphnia dubia* 7-day survival and reproduction test (Environment Canada 1992a);
- the fathead minnow (*Pimephales promelas*) 7-day survival and growth test (Environment Canada 1992b);
- the *Selenastrum capricornutum* 3-day algal growth test, (Environment Canada 1992c); and
- the duckweed (*Lemna minor*) 7-day growth test (Saskatchewan Research Council, 1995, 1996).

The duckweed tests were carried out by the Saskatchewan Research Council, in Saskatoon. The other three tests were completed at BEAK's Brampton, Ontario toxicity testing facility.

Bioassay procedures included use of dilution water collected from the site (Myra Creek, upstream of any mine influence) or laboratory water adjusted to the hardness of field conditions, depending on acclimation success with site water for *Ceriodaphnia dubia* and *Pimephales promelas*. In addition to the toxicity testing, using acclimated organisms, required for this study, a comparative study of chronic toxicity using both site dilution water and hardness adjusted laboratory water and non-acclimated animals is presented in a separate document for the three mines where effluent toxicity was measured (BEAK and Golder, 1998b). Results of this comparative study showed that site dilution water and laboratory dilution water produced comparable results in these tests.

Upon receipt at BEAK's laboratory, a subsample of each effluent and dilution water sample was forwarded to Philip Analytical Services. Samples were processed (filtered as appropriate and preserved) and analyzed for the water chemistry parameters identified in Section 3.4.

3.4 Water Chemistry

Detailed field sampling procedures are outlined in Annex 1 (provided as a separate document) and summarized in this section.

3.4.1 Field

All water samples were collected on 13 September 1997 so that relative metal concentrations at all locations were representative of the same effluent quality. Samples were collected for laboratory analysis of:

- total and dissolved metals (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Sr, Ta, Sn, U, V, B and Zn); Zn, Cu, Pb, and Cd are most relevant at Myra Falls;
- nutrients (nitrate, nitrite, ammonia, P);
- major ions (including sulphate);
- acidity, alkalinity, hardness, specific conductance;
- pH;
- colour;
- dissolved organic and inorganic carbon;
- solids (total suspended and dissolved); and
- turbidity.

In addition to samples collected for laboratory analysis, field determinations were made of specific conductance, temperature, pH and dissolved oxygen, with results recorded on field habitat record forms. All field measurements were made on-site using calibrated meters.

All samples were placed on ice in coolers immediately after collection, and were transferred to a refrigerator prior to field processing. All samples requiring analysis without chemical preservation were kept chilled until delivery to the laboratory.

Sample containers, filtration and sample preservation procedures are identified in Annex 1, and include use of high density polyethylene containers confirmed free of measurable metal contamination, ultrapure nitric acid and de-ionized distilled water also confirmed by the lab to be free of measurable metal contamination (for field, trip and filter blanks), and a filtration procedure using polypropylene syringes with 0.45 micron syringe-filters. All sample preparation was carried out in a clean indoor work space.

Quality control/quality assurance procedures followed in the field included collection of sample duplicates, and preparation of trip blanks, field blanks and filter blanks (Quality Control auditor's report provided in Appendix 2).

3.4.2 Laboratory

All water samples were forwarded to the analytical laboratory (Philip Analytical Services Corporation, Burlington and Mississauga, Ontario) within 48 hours of collection. Procedures used for laboratory analysis are summarized in Table A3.4, Appendix 3.

Results of QA/QC analyses indicated apparent contamination of the field blank and filter blanks (Appendix 2). No contamination was noted in the travel blank. Minor zinc, aluminum, chromium, and lead contamination was found in the filter blanks and likely originates from the filters as these contaminants were not found in the field blank, which received the same de-ionized water that was used to obtain the filter blanks. There was notable copper contamination in the field blank which appears to have originated from the de-ionized water carried on-site, because this contamination was not apparent in any of the hidden duplicates or in the trip blank, but was also apparent in the filter blanks. This contamination did not result in a serious problem for the testing of hypotheses, because water chemistry tools were not tested at Myra Falls and because the contamination appeared to originate from the de-ionized water which was not used in the collection of water at the stations. Sample containers were triple rinsed with site water before sample collection.

3.5 Sediment Chemistry

Annex 1 (provided as a separate report) provides more detail on procedures followed in the field for the collection and handling of sediment samples, which are summarized below.

Myra Creek

Sediment samples were not collected in Myra Creek as soft sediments are not available.

Buttle and Brewster Lakes

Sediment samples were collected from seven stations per area following benthic invertebrate sampling using a standard stainless steel Ponar grab connected to a power winch. Sediments were collected from depths ranging from 30 to 41 m. Ten to fifteen grab samples were collected at each station depending on the quantity of material retrieved in each grab. Sediment pH and redox potential were measured from several minimally disturbed sediment grabs at each station before the composite samples were collected.

Upon retrieval of the grab, surface water was allowed to run-off before the Ponar was placed into a plastic tub. The top 2 to 3 cm of sediment was collected using a stainless steel spoon and placed into a 20L bucket with a plastic liner. This procedure was repeated with each grab and new material was thoroughly mixed with the previous material until a total of eight litres of sediment per station had been collected. Subsamples of the homogenized sediment sample were dispensed into appropriate sample containers.

Three different types of sediment samples were collected for analysis from each site:

- a sample for "total" metals analysis, based on a nitric acid/hydrogen peroxide extraction procedure;
- a sample for "partial" metals analysis using a hydroxylamine hydrochloride procedure which is designed to solubilize amorphous Fe and Mn oxyhydroxides, along with their associated trace metals; and
- a sample for analysis of Acid Volatile Sulphide (AVS) and Simultaneously-Extracted Metals (SEM).

In addition, two field duplicate samples were collected for total metal determinations using extraction with aqua regia, to confirm the comparability of results using aqua regia and nitric acid/hydrogen peroxide extractions. Subsamples for partial metal extraction were collected by filling half a sample bottle with sediment, which was then topped with a layer of water. These samples were frozen at the end of the day. Subsamples for SEM/AVS analyses were placed into a 250 mL whirl-pak bag, and then into a 1-L jar once the air had been removed from the bag. The 1-L jar was then filled with sediment so that the whirl-pak bag was surrounded by sediment to prevent exposure to air.

Samples for chemical analysis were forwarded to Philip Analytical Services. Analyses included metals (total and partial), moisture, bulk density, Munsell colour, total organic carbon (TOC), loss-on-ignition (LOI), grain size and SEM and AVS.

Quality control/quality assurance procedures in addition to routine lab QA/QC included collection of hidden duplicate samples for metal analysis. One notable data comparability concern is raised concerning the high metal concentrations reported in the SEM fraction relative to concentrations reported as total metals (Appendix 2). Based on investigation, this appears to be caused by differences in the dry weight-wet weight conversion factors used at the chemistry laboratory. However, the same biases will apply to the AVS values, so that the SEM/AVS ratio should be unaffected by this calculation (i.e., the same bias applies to SEM and AVS in any single sample).

3.6 Sediment Toxicity

Sediment samples for toxicity testing were collected from Buttle and Brewster Lakes. Seven litres of sediment were collected from each of the seven stations located in the near-field, far-field and reference areas, described above (Section 3.5), and were placed in 20-L plastic food-grade buckets with polyethylene bag liners.

Toxicity tests conducted on each sample included: *Hyalella azteca* survival and growth (Environment Canada, 1996 Draft Method); *Chironomus riparius* survival and growth (Environment Canada, 1997 Draft Method); and *Tubifex tubifex* survival and reproduction (ASTM E1384-94A, 1995). *Chironomus* and *Hyalella* tests were conducted at BEAK's toxicity testing laboratory in Dorval, Quebec, whereas the *Tubifex* tests were completed at the National Water Research Institute, Environment Canada, in Burlington, Ontario.

3.7 Benthic Invertebrates

3.7.1 Field

Myra Creek

Benthic invertebrate samples were collected from ten stations in each of the reference and exposure areas in Myra Creek using a 0.1 m^2 T-sampler with a 250 µm mesh net. Stations within each area were selected based on appropriate riffle habitat. Stations selected in the reference area spanned a distance of approximately 200 m while in the exposure area, the ten stations spanned a distance of about 329 m. Five benthic grabs were collected and pooled at each of the ten stations. Samples were collected by manually removing invertebrates from rock surfaces and disturbing the underlying sand and gravel repetitively to a depth of about 10 cm. All collections were made by the same field crew member. Habitat characteristics, pH, temperature, dissolved oxygen, conductivity, flow and a photograph were taken at each station. Benthic invertebrate samples were preserved to a minimum level of 10% buffered formalin.

Buttle and Brewster Lakes

Benthic invertebrates samples were collected from each of the seven stations in each area. At each station five petite-Ponar grab samples were collected from depths of 30 to 42 m and pooled. Each of the five grab samples was sieved using a 250 μm mesh screen prior to preservation to a minimum level of 10% buffered formalin. All samples were collected by the same field crew member.

3.7.2 Lab Processing

All samples were processed jointly by the BEAK's Benthic Ecology Laboratory and by Zaranko Environmental Assessment Services (ZEAS), Guelph, Ontario. Both laboratories followed the same laboratory protocols summarized below.

In the laboratory, samples were inspected to insure that they were adequately preserved and correctly labelled. Samples were then stained to improve the sorting recovery.

Prior to detailed sorting, the samples were washed free of formalin in a 250 μm sieve under ventilated conditions. The benthic fauna and associated debris were then elutriated free of any sand and gravel. The remaining sand and gravel fraction was closely inspected for any of the denser organisms, such as Pelecypoda, Gastropoda, and Trichoptera with stone cases that may not have all been washed from this fraction. The remaining debris and benthic fauna after elutriation were washed through 500 μm and 250 μm sieves to standardize the size of the debris being sorted and facilitate a minimum of 95% recovery of benthic fauna.

All benthic samples were processed with the aid of stereomicroscopes. A magnification of at least 10X was used for macrobenthos (invertebrates >500 μm) and 20X for meioinvertebrates (invertebrate size >250 to <500 μm). Benthos was sorted from the debris, enumerated into the major taxonomic groups, usually order and family levels and placed in vials for more detailed taxonomic analysis.

Benthic invertebrates were most commonly identified to the lowest practical level, genus or species for most groups. The level to which each group was identified and the taxonomic keys that the identification were based on are provided in Appendix 5.

For meeting the data quality objectives, subsampling error was determined for both density and number of taxa in 10% of the samples that were subsampled. Ten percent of sorted samples were also resorted by an independent taxonomist to ensure 95% recovery of all invertebrates.

A voucher collection or reference collection of benthic invertebrate specimens was compiled. This is a collection of representative specimens for each taxon so that there can be continuity in taxonomic identifications if different taxonomists process future samples. The voucher collection will be maintained at BEAK. The BEAK Benthic Ecology Laboratory also maintains a master reference collection of all taxa which have been identified by the lab.

The specimens selected for the voucher collection were preserved such that they will remain intact for many years. Chironomids and oligochaetes remain on the initial slides and representatives of each taxon were circled with a permanent marker and labelled. All other species were preserved in 80% ethanol in separately labelled vials. Each vial contains a 3% solution of glycerol to prevent spoilage of the fauna if the vials accidentally dry out.

3.7.3 Chironomid Deformities

In the last decade there has been considerable attention paid towards the use of chironomid mouth part deformities to monitor contaminant effects. Previous studies have shown that the incidence of chironomid deformities (especially in *Chironomus*) can be associated with contaminated sediments.

For the 1997 study, all mounted chironomid specimens from each site were scored for mandible and mentum abnormalities. These data were not used in the testing of specific hypotheses, but are discussed briefly in Section 4.4.

3.8 Fish

All fish related hypotheses were dropped from the Myra Falls site and this effort was redirected to another site that had better potential to successfully test these hypotheses (i.e., Mattabi Mine).

4.0 DATA OVERVIEW

4.1 Effluent Chemistry and Toxicity

Effluent Chemistry

Effluent chemistry data for four samples collected on 02 July, 14 August, 30 September and 01 December 1997 are provided in Table 4.1. Concentrations of chemicals in the mine effluent were compared to the MMLER. Regulations, based on monthly averages and grab sample limits, exist for arsenic, copper, lead, nickel, and zinc, pH, and total suspended solids. Although some variability was observed in these chemical parameters among different sampling dates, levels remained below the MMLER values in all effluent samples collected.

The average effluent sulphate concentration bracketing the time of the field survey (14 August and 30 September) was 616 mg/L compared with an average measurement in the Myra Creek exposure area of 88 mg/L. This indicates that the effluent concentration was around 14% in the exposure area in the creek. The average effluent zinc concentration over the same time period was 0.078 mg/L. Therefore, the concentration in the creek exposure area would be expected to be around 0.012 mg/L, but was in fact 30 times higher than predicted at 0.362 mg/L, indicating that there are other sources of zinc entering the creek.

Effluent Toxicity

Fathead minnows were not affected by Westmin Resources effluent as LC50s and IC25s were >100% in the four samples tested (Table 4.2, Figure 4.1). Interestingly, the minnows could not be acclimated to the receiving water collected in the latter half of the program (30 September, 01 December) due to fungal infections. *Ceriodaphnia dubia* were more sensitive to mine effluent as 50% mortality was observed at an average effluent concentration of 72% (v/v).

Sublethal effects were observed in 25% of the test organisms (i.e., IC25s) at average effluent concentrations of 36%, 38% and 44% (v/v) for *Ceriodaphnia*, *Selenastrum* and *Lemna minor*, respectively. The IC25s for individual samples for *Ceriodaphnia* and

Table 4.1: Effluent Chemistry for Samples collected at Myra Falls, 1997.

Parameter	Units	LOQ[1]	MMLER[2] Monthly Mean	MMLER[2] Grab Sample Maximum	M-E-1 (Total) 97/07/03	M-E-1 (Dissolved) 97/07/03	M-E-2 (Total) 97/08/14	M-E-2 (Dissolved) 97/08/14	M-E-3 (Total) 97/09/30	M-E-3 (Dissolved) 97/09/30	M-E-4 (Total) 97/12/02	M-E-4 (Dissolved) 97/12/02
Acidity(as CaCO3)	mg/L	1	na[3]	na[3]	-[4]	-	-	-	-	nd	-	nd
Alkalinity(as CaCO3)	mg/L	1	na	na	27	-	41	-	19	-	22	-
Aluminum	mg/L	0.01	na	na	0.44	0.27	0.19	0.17	0.27	0.12	0.31	0.2
Ammonia(as N)	mg/L	0.05	na	na	1.7	-	1.53	-	1.19	-	1	-
Antimony	mg/L	0.002	na	na	nd[5]	nd	nd	nd	0.0016	0.0008	0.002	0.0017
Arsenic	mg/L	0.002	0.5	1.0	0.002	0.002	nd	nd	nd	nd	nd	nd
Barium	mg/L	0.005	na	na	0.027	0.025	0.03	0.029	0.034	0.029	0.028	0.022
Beryllium	mg/L	0.005	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	mg/L	1	na	na	20	-	38	-	12	-	8	-
Bismuth	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Boron	mg/L	0.005	na	na	0.04	0.04	0.057	0.051	0.02	0.014	0.021	nd
Cadmium	mg/L	0.0005	na	na	0.0028	0.0008	nd	nd	0.00072	0.00026	0.00042	0.00016
Calcium	mg/L	0.1	na	na	263	276	313	304	222	229	164	177
Carbonate(as CaCO3, calculated)	mg/L	1	na	na	6	-	3	-	5	-	8	-
Chloride	mg/L	1	na	na	13	-	17	-	9	-	7	-
Chromium	mg/L	0.002	na	na	nd	nd	nd	nd	0.0007	0.0005	0.001	0.0016
Cobalt	mg/L	0.001	na	na	nd	nd	nd	nd	0.0006	0.0011	0.0004	nd
Colour	TCU	5	na	na	17	-	nd	-	24	-	nd	-
Conductivity - @25øC	us/cm	1	na	na	1330	-	1510	-	978	-	874	-
Copper	mg/L	0.002	0.3	0.6	0.007	0.005	0.016	0.003	0.017	0.002	0.01	0.0011
Dissolved Inorganic Carbon(as C)	mg/L	0.5	na	na	-	10.1	-	8.1	-	0.9	-	5.5
Dissolved Organic Carbon(DOC)	mg/L	0.5	na	na	-	5.4	-	2.8	-	2.1	-	2.7
Hardness(as CaCO3)	mg/L	0.1	na	na	706	-	764	-	584	-	464	-
Iron	mg/L	0.02	na	na	0.05	nd	-	-	0.26	nd	0.08	nd
Lead	mg/L	0.0001	0.2	0.4	0.0004	nd	0.001	0.0002	0.0039	0.0003	0.0012	0.0013
Magnesium	mg/L	0.1	na	na	3.8	3.8	1.1	0.9	2.8	2.8	5	5.3
Manganese	mg/L	0.002	na	na	0.087	0.031	0.006	nd	0.045	0.0027	0.023	0.0034
Mercury	mg/L	0.0001	na	na	nd	nd	0.0002	nd	nd	nd	nd	nd
Molybdenum	mg/L	0.002	na	na	0.042	0.045	0.075	0.075	0.034	0.031	0.028	0.023
Nickel	mg/L	0.002	0.5	1.0	0.003	0.002	0.01	0.008	nd	nd	nd	nd
Nitrate(as N)	mg/L	0.05	na	na	2.1	-	2.29	-	1.66	-	1.59	-
Nitrite(as N)	mg/L	0.01	na	na	nd	-	0.24	-	0.06	-	nd	-
Orthophosphate(as P)	mg/L	0.01	na	na	nd	-	0.45	-	nd	-	nd	-
pH	Units	0.1	6.0 [6]	5.0 [6]	9.5	-	8.9	-	9.7	-	10	-
Phosphorus	mg/L	0.1	na	na	0.2	0.2	0.2	nd	nd	nd	nd	nd
Phosphorus, Total	mg/L	0.01	na	na	-	0.18	-	0.2	-	0.09	-	0.06
Potassium	mg/L	0.5	na	na	18	18.1	15.9	15.9	9	10.1	7.2	7.3
Reactive Silica(SiO2)	mg/L	0.5	na	na	3.4	-	4.4	-	3.8	-	3.8	-
Selenium	mg/L	0.002	na	na	0.022	0.022	nd	nd	0.015	0.016	0.008	0.006
Silver	mg/L	0.0005	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Sodium	mg/L	0.1	na	na	24.8	25.8	25.8	25.9	13.4	15	12	12.8
Strontium	mg/L	0.005	na	na	1.08	1.08	1.33	1.32	0.85	0.87	0.87	0.73
Sulphate	mg/L	2	na	na	669	-	715	-	517	-	442	-
Thallium	mg/L	0.0001	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Tin	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	mg/L	0.002	na	na	0.012	0.009	0.004	0.002	0.008	nd	0.008	0.007
Total Dissolved Solids(Calculated)	mg/L	1	na	na	-	1040	-	1120	-	807	-	677
Total Kjeldahl Nitrogen(as N)	mg/L	0.05	na	na	2.44	-	1.95	-	1.43	-	1.34	-
Total Suspended Solids	mg/L	5	25.0	50.0	5	-	nd	-	20	-	11	-
Turbidity	NTU	0.1	na	na	0.9	-	0.2	-	10.7	-	12.1	-
Uranium	mg/L	0.0001	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	mg/L	0.002	0.5	1.0	0.468	0.017	0.017	0.002	0.14	0.009	0.006 [6]	0.006 [6]

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
[2] MMLER = Metal Mining Liquid Effluent Regulations (Fisheries Act, 1994)
[3] na = Regulation values not available
[4] - = Not Analyzed
[5] nd = Parameter not detected
[6] suspect values

Table 4.2: Results of Effluent Toxicity Tests Conducted on Four Myra Falls Effluent Samples, 1997.

(Expressed as % Effluent. Values in parentheses represent the 95% confidence interval)

Sample	*Ceriodaphnia dubia* (Water Flea)			*Pimephales promelas* (Fathead Minnow)			*Selenastrum capricornutum* (Algae)		*Lemna minor* (Duckweed)	
	LC50	IC25	IC50	LC50	IC25	IC50	IC25	IC50	IC25	IC50
M-E-1 02 July 97	46.7 (36.1-60.2)	22.2 (13.4-29.8)	33.8 (23.8-38.8)	>100 na	>100 na	>100 na	31.4 (24.9-37.4)	42.8 (37.3-66.2)	not tested	not tested
M-E-2 13 Aug. 97	89.1* (66.1-180)	15.8* (4.30-26.8)	28.5* (19.8-35.9)	>100 na	>100 na	>100 na	71.0 not calculable	>100 na	19.2 (7.9-46.8)	72.8 (49.0-93.1)
M-E-3 30 Sept. 97	>100 na	56.1 (36.2-67.0)	81.5 (65.9-91.5)	>100** na	>100** na	>100** na	18.1 (8.70-23.6)	31.8 (19.9-40.0)	67.4 (59.5-76.3)	89.1 (80.7-93.1)
M-E-4 01 Dec. 97	53.8 (37.3-80.6)	49.7 (12.0-63.2)	67.7 (42.0-76.5)	>100** na	>100** na	>100** na	32.7 (26.8-34.0)	40.4 (36.8-43.1)	45.6 (34.4-60.4)	92.5 (76-93.1)

Notes:

* *Ceriodaphnia* test reset - LC50 may be overestimated

All tests conducted using Myra Creek dilution water except where indicated by "**".

** tests conducted using laboratory water (adjusted to site water hardness, pH and alkalinity) as dilution water because fatheads could not be acclimated due to pathogens.

Ceriodaphnia and fathead minnows were acclimated to physl/chem of dilution water prior to testing, where possible.

Fathead minnow data analysed according to Environment Canada amendments (Nov. 1997) - IC values represent growth effects alone.

Lemna were similar, whereas the results for *Selenastrum* were not as comparable to the results for these two test organisms (Table 4.2).

The toxicity data suggest that a 3:1 effluent dilution in Myra Creek should minimize the potential for sublethal effects on aquatic organisms in the creek. If the lowest IC25 is used (i.e., IC25 of 16% for *Ceriodaphnia*), then a 6:1 dilution factor would be required to minimize the potential for sublethal effects in the creek. Effluent concentration in the area where water samples and benthos were collected was calculated to be approximately 15% effluent. Therefore, based on the effluent toxicity test results it would be predicted that there should be no effects on the aquatic communities downstream of the discharge. However, as demonstrated above, there are other sources of contaminants entering the stream that are not accounted for with toxicity tests on the treated effluent.

4.2 Water Chemistry

Selected water chemistry data for the Myra Falls site are summarized in Table 4.3 (total metals and general chemistry) and Table 4.4 (which compares total versus dissolved metals). Detailed data for all parameters measured are provided in Appendix 5. QA/QC data associated with water chemistry analyses are provided in Appendix 2, Table A2.2.

Myra Creek

Concentrations of cadmium, cobalt, copper, nickel, potassium, and zinc were below method detection limits at the reference area and above detection limits in the exposure area, suggesting the mine discharge and seepages as sources of these contaminants. Concentrations of aluminum, calcium, iron, magnesium, manganese, sodium and strontium were higher in the exposure area compared to levels in the reference area. However, concentrations of these parameters in both areas were below Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life (CCREM, 1987). Concentrations of copper and zinc were the only contaminants found to exceed the CWQG in the exposure area. Total concentrations of all other metals were below detection limits in both areas.

Concentrations of nutrients (e.g., ammonia, nitrate, nitrite, total Kjeldahl nitrogen) sulphate and chloride were above detection limits in the exposure area and below detection limits in the reference area (Appendix 5, Table A5.1) suggesting that the mine effluent and

Table 4.3: Selected Water Chemistry Results at Myra Falls, 12-13 September 1997

				REFERENCE STATIONS (LAKE)			NEAR FIELD STATIONS (LAKE)				FAR FIELD STATIONS (LAKE)			REFERENCE STATIONS (CREEK)			EXPOSURE STATIONS (CREEK)		
Parameter	**Units**	**LOQ[1]**	**CWQG[2]**	MR1	MR3	MR7	MN4	MN4S[8]	MN7	MN10	MF1	MF3	MF7	MCR1	MCR5	MCR10	MCE1	MCE5	MCE10
Total Metals																			
Aluminum	mg/L	0.005	0.1	0.062	0.065	0.06	0.019	0.017	0.02	0.017	0.013	0.013	0.017	0.023	0.025	0.023	0.054	0.054	0.053
Cadmium	mg/L	0.00005	0.0002/0.00083	nd[7]	nd	nd	0.00007	nd	0.00007	0.00007	nd	nd	nd	nd	nd	nd	0.00057	0.00054	0.00056
Copper	mg/L	0.0003	0.002	0.0011	0.001	0.0009	0.0014	0.0009	0.0014	0.0012	0.0009	0.0008	0.001	nd	nd	nd	0.0104	0.0094	0.0103
Iron	mg/L	0.02	0.3	0.04	0.04	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.04	0.04	0.04
Lead	mg/L	0.0001	0.001/0.002 4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Manganese	mg/L	0.0005	na 5	0.0011	0.0012	0.001	0.0056	0.004	0.0046	0.0031	0.002	0.0016	0.0028	nd	0.0005	nd	0.192	0.179	0.19
Nickel	mg/L	0.001	.025/.0656	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.002	0.002	0.002
Zinc	mg/L	0.001	0.03	0.002	nd	nd	0.032	0.016	0.031	0.023	0.015	0.017	0.014	nd	nd	nd	0.372	0.346	0.367
General Chemistry																			
Sulphate	mg/L	2	na	nd	nd	nd	8	6	8	6	5	5	5	nd	nd	nd	90	87	88
Alkalinity(as CaCO3)	mg/L	1	na	10	11	10	25	21	23	23	24	24	25	13	13	13	15	15	15
Colour	TCU	5	na	20	20	20	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Conductivity - @25øC	us/cm	1	na	26	25	25	59	55	61	56	55	53	56	27	26	27	220	200	220
Dissolved Organic Carbon(DOC)	mg/L	0.5	na	5.4	3.6	2.7	1.1	1.1	1.2	1	0.7	0.9	0.8	0.8	0.8	1	0.8	0.7	1
Field pH	Units	0.1	6.5 - 9.0	6.54	6.66	6.7	7.05	7.13	7.08	7.09	7.23	7.25	7.15	7.05	6.9	7.18	7.78	7.3	-
Hardness(as CaCO3)	mg/L	0.1	na	10.9	10.9	10.8	31	25.1	30	28.7	28.3	27.6	28.5	12.7	12.7	12.8	102	102	98.8
Total Dissolved Solids(Calculated)	mg/L	1	na	17	18	17	40	31	38	36	35	34	36	17	17	17	150	146	146
Total Suspended Solids	mg/L	1	na	nd	nd	nd	nd	nd	nd	nd	nd	nd	1	1	nd	nd	nd	nd	nd

1 LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence

2 CWQG - Canadian Water Quality Guidelines (CCREM, 1987)

3 Cadmiun Guideline values - 0.0002 mg/L (Hardness 0-60), 0.0008 mg/L (Hardness 60-120)

4 Lead Guideline values - 0.001 mg/L (Hardness 0-60), 0.002 mg./L (Hardness 60-120)

5 na - Guideline values not available

6 Nickel Guideline values - 0.025 mg/L (Hardness 0-60), 0 065 mg/L (Hardness 60-120)

7 nd = Parameter not detected

8 MN4S = surface water sample

[shaded] - Denotes values that exceed the guideline

Table 4.4: Total versus Dissolved Concentrations for Selected Metals in Water Samples Collected at Myra Falls, 12-13 September 1997

			REFERENCE STATIONS (LAKE)						NEAR-FIELD STATIONS (LAKE)							
			MR1	MR1	MR3	MR3	MR7	MR7	MN4	MN4	MN4S[3]	MN4S	MN7	MN7	MN10	MN10
Parameter	**Units**	**LOQ[1]**	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	mg/L	0.005	0.062	0.054	0.065	0.053	0.06	0.054	0.019	0.023	0.017	0.021	0.02	0.013	0.017	0.013
Cadmium	mg/L	0.00005	nd [2]	nd	nd	nd	nd	nd	0.00007	0.00007	nd	nd	0.00007	0.00006	0.00007	0.00006
Copper	mg/L	0.0003	0.0011	0.0016	0.001	0.0016	0.0009	0.0021	0.0014	0.0027	0.0009	0.0019	0.0014	0.0034	0.0012	0.0033
Lead	mg/L	0.0001	nd	nd	nd	nd	nd	nd	nd	0.0005	nd	0.0005	nd	nd	nd	nd
Manganese	mg/L	0.0005	0.0011	0.0005	0.0012	0.0006	0.001	nd	0.0056	0.0025	0.004	0.0012	0.0046	0.0012	0.0031	0.0006
Zinc	mg/L	0.001	0.002	0.004	nd	0.006	nd	0.005	0.032	0.035	0.016	0.02	0.031	0.033	0.023	0.025

			FAR-FIELD STATIONS (LAKE)						REFERENCE STATIONS (CREEK)						EXPOSURE STATIONS (CREEK)					
			MF1	MF1	MF3	MF3	MF7	MF7	MCR1	MCR1	MCR5	MCR5	MCR10	MCR10	MCE1	MCE1	MCE5	MCE5	MCE10	MCE10
Parameter	**Units**	**LOQ**	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	mg/L	0.005	0.013	0.009	0.013	0.02	0.017	0.009	0.023	0.022	0.025	0.025	0.023	0.025	0.054	0.043	0.054	0.041	0.053	0.04
Cadmium	mg/L	0.00005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00057	0.00053	0.00054	0.0005	0.00056	0.00052
Copper	mg/L	0.0003	0.0009	0.001	0.0008	0.002	0.001	0.0013	nd	0.0008	nd	0.0013	nd	0.0007	0.0104	0.0075	0.0094	0.0078	0.0103	0.0079
Lead	mg/L	0.0001	nd	nd	nd	0.0012	nd	nd	nd	nd	nd	0.0002	nd	nd	nd	0.0006	nd	0.0004	nd	0.0003
Manganese	mg/L	0.0005	0.002	nd	0.0016	0.001	0.0028	0.0008	nd	nd	0.0005	0.0007	nd	0.0006	0.192	0.178	0.179	0.178	0.19	0.19
Zinc	mg/L	0.001	0.015	0.016	0.017	0.023	0.014	0.016	nd	0.004	nd	0.004	nd	0.005	0.372	0.369	0.346	0.345	0.367	0.365

[1] LOQ = Limit of Quantitation = lowest level of paramater that can be quantified with confidence

[2] nd = Parameter not detected

[3] MN4S = surface water sample

seepage from other areas are sources of nutrient enrichment of Myra Creek. Conductivity, hardness and total dissolved solids increased substantially from the reference area to the exposure area and are reflective of the effluent treatment process used by the mine.

In general, increases in the concentrations of most chemical parameters were observed in the exposure area compared to the reference area in Myra Creek.

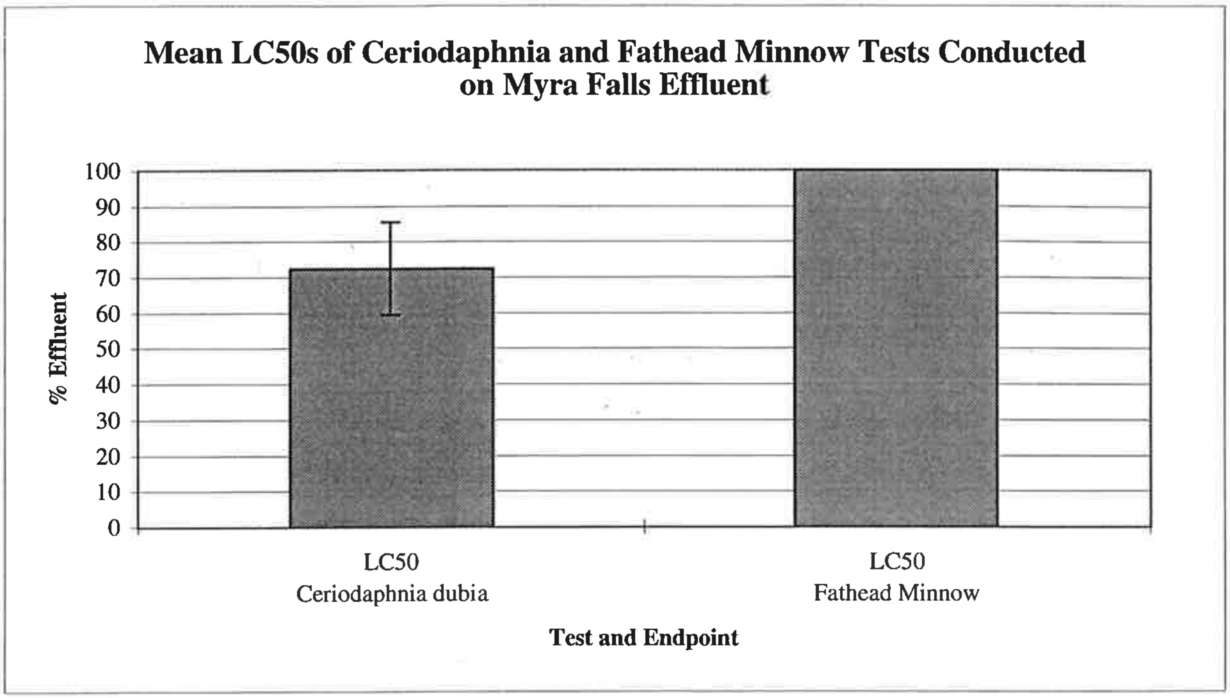
Buttle and Brewster Lakes

Concentrations of metals above detection limits in near-field, far-field and reference stations in Buttle and Brewster lakes included: aluminum, calcium, copper, iron, magnesium, manganese, sodium and strontium. Only concentrations of manganese, strontium and zinc showed a decreasing trend with increased distance from Myra Falls; no trend was observed in the other parameters. Zinc concentrations were equal to the CWQG for the protection of aquatic life at two stations in the near-field area.

General water chemistry differed for some parameters between the exposure and reference lakes. Colour, dissolved organic carbon, and total Kjeldahl nitrogen concentrations were higher in the reference lake compared to levels in the exposure lake, whereas concentrations of most other parameters were lower in the reference lake. There were no trends in the concentrations of general water chemistry parameters relative to increased distance from the Myra Falls mine site.

Total versus Dissolved Metals

Concentrations of selected dissolved and total metals are provided in Table 4.4. The full data set is provided in Appendix 5. Comparisons of dissolved and total metal concentrations for cadmium, copper, and zinc which best represent the trend in water chemistry are provided in Figure 4.2. The concentrations of dissolved metals were higher than the corresponding total metal concentrations in some samples (e.g., aluminum, calcium, copper, iron and zinc). This is not unusual when measuring elements with low concentrations, (i.e., close to or below the detection limit) and may be attributed to the following factors: analytical variability; contamination in the field during sample collection; or contamination of collection bottles or preservative. In addition, filter blanks showed metal concentrations (Al, Cr, Cu, Fe, Pb, Zn) above detection limits indicating a



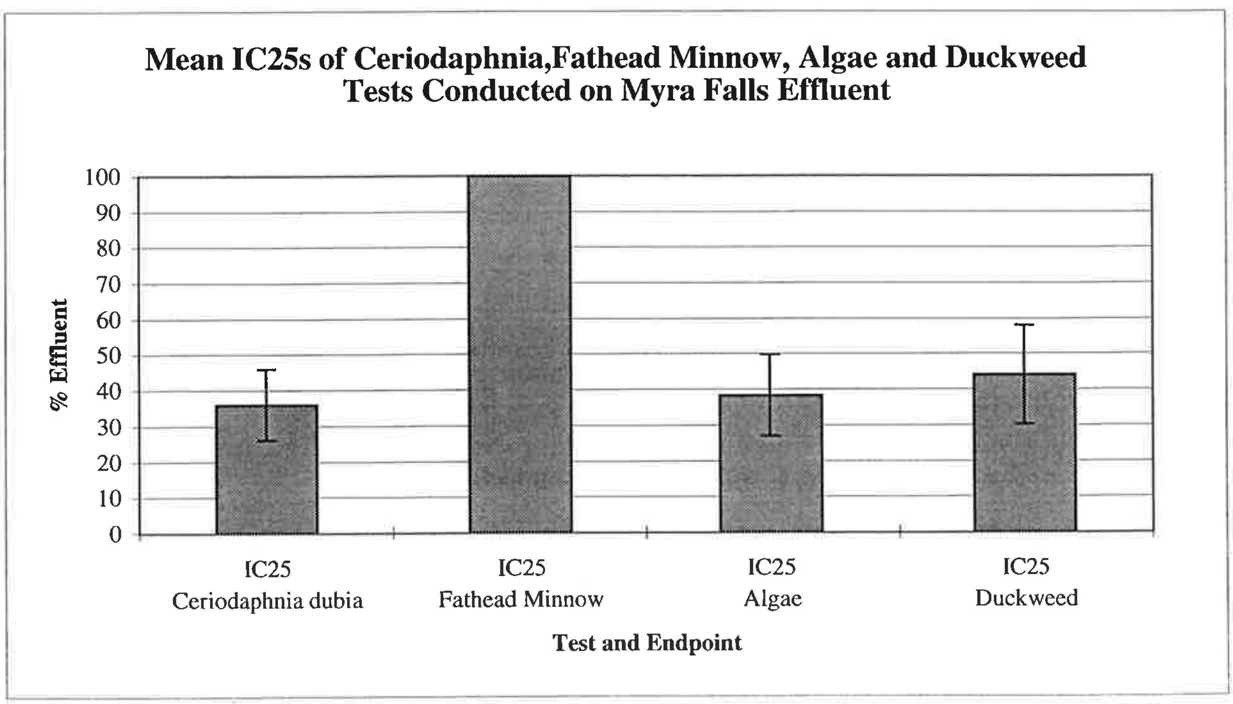
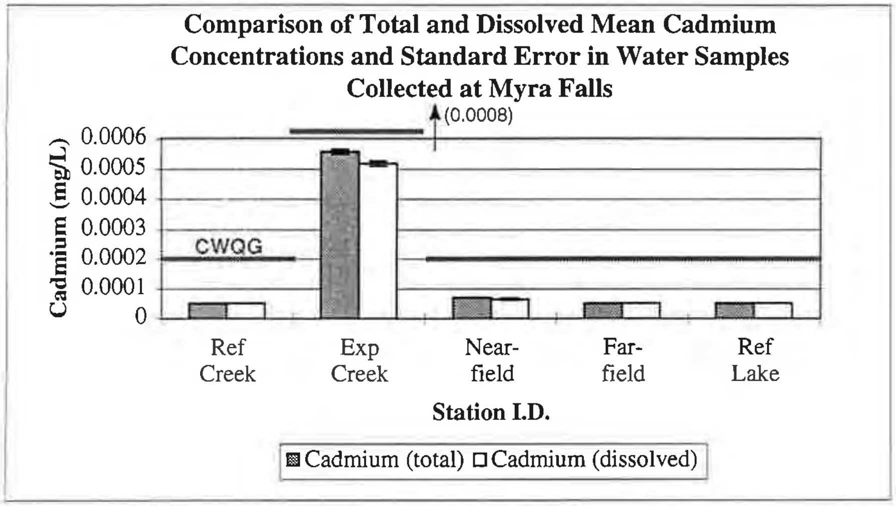
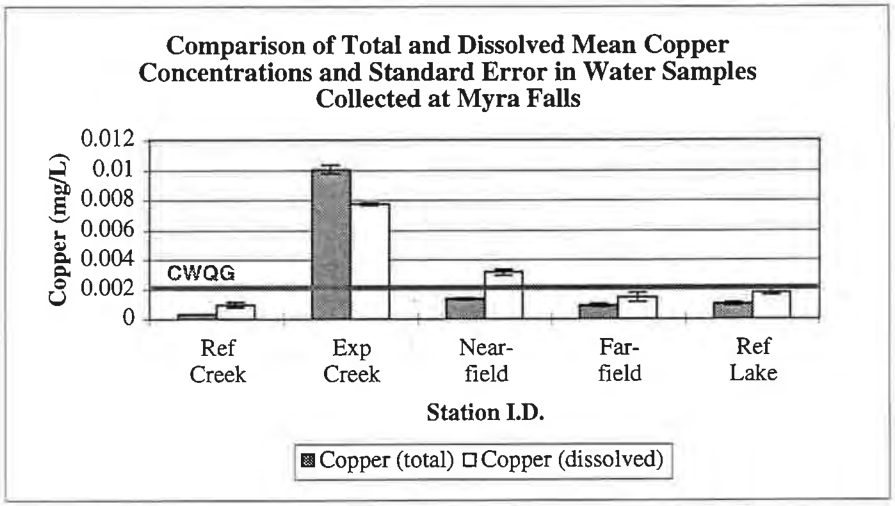


Figure 4.1: Mean Effluent Toxicity Test Results (± 1 S.E.), Based on Four Species with Four Myra Falls Effluent Samples (3 tests for Duckweed), September 1997.
Based on Data Presented in Table 4.2.





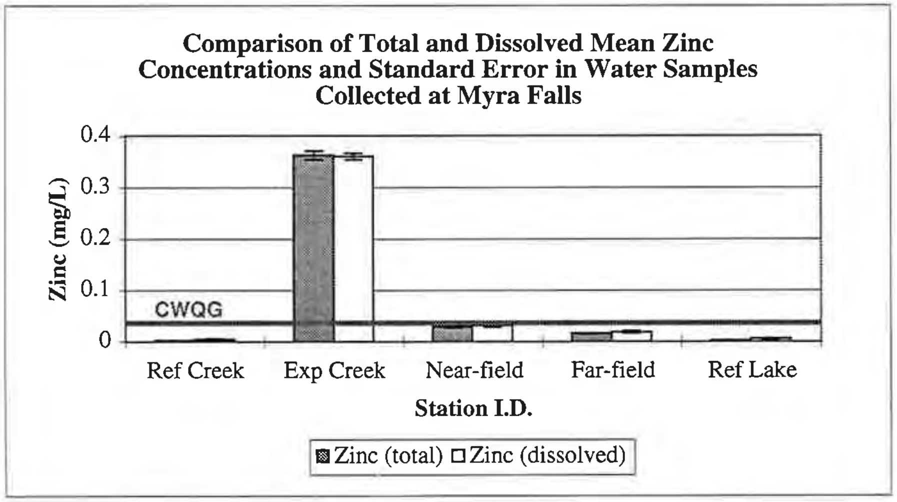


Figure 4.2: Mean Total and Dissolved Metal Concentrations at Reference and Exposure Areas. Myra Falls, 12-13 September 1997. Area Means (± 1 S.E.) Based on Data in Table 4.4. CWQG = Canadian Water Quality Guideline. Note - CWQG varies for Cadmium in response to water hardness.

source of contamination during filtering of the sample (Appendix 2, Table A2.2). Some of these metals were below detection limits in the upstream samples. However, any contamination from the filtering process appeared to be insignificant when the data are compared to the CWQG (Table A2.2).

In general, field and laboratory replicates were in agreement although analytical variability was observed in some samples (e.g., dissolved copper in sample MN7-W, Appendix 2, Table A2.2). For most metals, a high percentage (generally > 80%) was in the dissolved form (Table 4.4, Figure 4.2).

4.3 Sediment Chemistry

No fine-grained sediment was available for collection from Myra Creek. Sediment chemistry data, for total metals, physical parameters, partial metals and acid volatile sulphide and simultaneously extracted metals in samples collected from Buttle and Brewster lakes are provided in Tables 4.5, 4.6 and 4.7, respectively. The total metal concentrations (Table 4.5) are compared to the Canadian Interim Sediment Quality Assessment Values (CISQV) (Environment Canada, 1995). The TEL (threshold effect level) value refers to the concentration below which an adverse effect is likely to rarely occur, whereas the PEL (probable effect level) value refers to the concentration above which one could frequently expect adverse effects (Environment Canada, 1995). All QA/QC data associated with the sediment chemistry analyses are provided in Appendix 2, Table A2.3.

Total Metal Concentrations and Physical Sediment Characteristics

Concentrations of arsenic, cadmium, copper, lead, and zinc exceeded the PEL at all seven stations in the near-field area (Table 4.5). In general, concentrations of these total metals, with the exception of cadmium and zinc exceeded the TEL in the reference area. Nickel concentrations exceeded TEL levels at the reference and near-field areas and exceeded PEL levels in the far-field area. There may be a natural source of nickel influencing the sediment chemistry in the far-field area. With the exception of nickel, a general decreasing trend in concentration with increased distance from the Myra Falls mine site was observed for most of the other key metals. Nickel concentrations showed the opposite trend with the highest concentrations found at the far-field stations.

Table 4.5: Selected Sediment Chemistry Results at Myra Falls, September 1997. Metals Results Represent Total Metals Analyses.

Parameter	Units	MDL[2]	ISQAV[3] TEL[4]	ISQAV[3] PEL[5]	REFERENCE STATIONS MR1	MR2	MR3	MR4	MR5	MR6	MR7	NEAR FIELD EXPOSURE STATIONS MN4	MN5	MN6	MN7	MN8	MN9	MN10	FAR FIELD EXPOSURE STATIONS MF1	MF2	MF3	MF4	MF5	MF6	MF7
TOC (Solid)	(%)	0.1	na[6]	na	6.2	6.3	6.5	6	6.2	5.9	5.7	2.2	2	2.4	3.4	2.4	3.3	3.4	4.2	5.5	5.5	3.4	4.2	4.2	2.8
Arsenic	mg/kg	0.5	5.9	17	13	14	13	13	13	13	21	73	59	60	83	89	53	59	22	15	9.6	15	14	32	10
Cadmium	mg/kg	0.05	0.596	3.53	0.35	0.35	0.34	0.39	0.4	0.39	0.42	12	13	7.8	10	9.5	9.7	9.9	1.1	3.1	2.3	0.86	1.1	2.1	1.4
Chromium	mg/kg	0.6	37.3	90	36	35	36	32	32	34	35	47	33	48	46	49	44	39	53	49	42	47	39	44	47
Copper	mg/kg	0.2	35.7	196.6	76	72	75	76	75	79	87	1100	1000	1300	1400	1500	1200	800	190	310	250	180	140	220	160
Lead	mg/kg	0.1	35.0	91.3	40	42	44	49	53	53	49	760	650	760	890	920	700	430	18	70	51	14	14	50	26
Manganese	mg/kg	1	na	na	19000	23000	15000	28000	26000	26000	36000	1600	1600	3000	7900	10000	2000	9100	2500	5000	1200	1400	1600	7800	1600
Nickel	mg/kg	0.5	18.0	35.9	19	19	20	20	20	21	26	30	21	33	29	32	29	29	47	43	41	50	37	40	40
Silver	mg/kg	0.05	na	na	0.25	0.24	0.27	0.29	0.29	0.29	0.25	11	15	11	12	11	8.9	7	0.34	0.64	0.48	0.3	0.33	0.54	0.42
Zinc	mg/kg	1	123.1	314.8	59	59	61	63	58	61	69	3000	2200	1900	2400	2600	2300	1600	240	630	430	220	170	390	240
Grain Size Analysis																									
Gravel (>2.0 mm)	%	0.1	na	na	0.2	0.2	0.2	0.3	0.4	1.5	0.3	0.2	0.3	0.8	0.7	2.3	0.9	2.4	3.6	3.9	1.7	0.3	0.8	1.3	1.2
Sand (0.050 - 2.0 mm)	%	0.1	na	na	63.4	81.8	63.4	63.2	79.8	79.6	77.6	29.8	26.4	26.3	32.5	18.2	27.9	27.2	30	30.8	37.2	20.3	24.3	27.7	17.5
Silt (0.002-0.050mm)	%	0.1	na	na	-	-	-	-	-	-	-	54	51	47	59	55	51	49	54	51	49	70	66	55	55
Clay (<0.002mm)	%	0.1	na	na	-	-	-	-	-	-	-	17	23	26	7.2	25	20	22	12	15	12	9.8	9.6	16	26
V. Fine Sand, Silt, Clay (<0.10mm[1])	%	0.1	na	na	37	18	36	38	20	19	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Due to high moisture content, there was insufficient sample to conduct hydrometer test for fines, silt and clay.
[2] MDL - Method detection limit - lowest level the parameter that can be detected with confidence
[3] ISQAV - Interim Sediment Qulality Assessment Values (Freshwater) (Environment Canada, 1995)
[4] ISQAV - Threshold Effect Level (TEL)
[5] ISQAV - Probable Effect Level (PEL)
[6] na - Guideline values not available

(grey) - Denotes values that exceed the Threshold Effect Level (TEL)
(black) - Denotes values that exceed the Probable Effect Level (PEL)

Table 4.6: Selected Sediment Chemistry Results at Myra Falls, September 1997. Metals Results Based on Partial Extraction.

Partial Metal Parameter	Units	MDL[1]	REFERENCE STATIONS							NEAR FIELD EXPOSURE STATIONS							FAR FIELD EXPOSURE STATIONS						
			MR1	MR2	MR3	MR4	MR5	MR6	MR7	MN4	MN5	MN6	MN7	MN8	MN9	MN10	MF1	MF2	MF3	MF4	MF5	MF6	MF7
Arsenic	mg/kg	0.5	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Cadmium	mg/kg	0.05	0.14	0.13	0.13	0.14	0.14	0.16	0.17	2.6	2.4	2.3	3.1	3	2.3	3.8	0.36	1.3	0.56	0.32	0.34	0.75	1.4
Chromium	mg/kg	0.6	7.2	6.4	6.5	6.2	7.1	5.9	5.7	4.4	4.6	5.4	5.2	5.3	4.9	5.2	6.1	6.7	4.5	5.6	6.3	6.4	5.6
Copper	mg/kg	0.2	3.8	3.9	3.5	4.2	5.3	4.8	6.1	25	42	51	61	80	6.3	63	7.3	17	2.4	12	15	10	36
Lead	mg/kg	0.1	6	5.5	6.2	5.3	7.7	5.1	5.8	230	270	230	270	240	220	120	1.4	9.5	5.4	1	0.9	5.1	4.2
Nickel	mg/kg	0.5	1.6	1.3	1.5	1.5	1.7	1.8	2.5	2	2.2	2.6	2.7	2.7	2.2	2.4	2.5	2.8	1.9	2.4	2.6	2.6	2.8
Silver	mg/kg	0.05	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Zinc	mg/kg	1	11	9.9	11	11	14	11	12	750	810	750	910	880	790	630	65	240	140	49	53	140	140

[1] MDL - Method detection limit - lowest level that the parameter can be detected with confidence

Table 4.7: Acid Volatile Sulphide (AVS) and Simultaneously Extracted Metals (SEM) Results and Ratios for Lake Sampling Stations at Myra Falls, September 1997

Component	Units	MDL[1]	REFERENCE STATIONS							NEAR FIELD EXPOSURE STATIONS							FAR FIELD EXPOSURE STATIONS						
			MR1	MR2	MR3	MR4	MR5	MR6	MR7	MN4	MN5	MN6	MN7	MN8	MN9	MN10	MF1	MF2	MF3	MF4	MF5	MF6	MF7
Cadmium	umol/g	0.05	<	<	<	<	<	<	<	0.1	0.1	0.2	0.1	0.1	0.0	0.1	<	0.1	0.0	<	<	0.0	<
Copper	umol/g	0.1	1.5	1.7	1.0	1.6	2.2	0.9	1.9	16.7	29.8	61.1	26.9	17.8	12.0	11.0	5.8	9.9	6.3	6.4	4.4	5.6	4.7
Lead	umol/g	0.4	0.3	0.4	0.3	0.4	0.6	0.2	0.4	4.5	8.3	12.5	6.0	3.9	2.6	1.9	<	0.7	0.4	<	<	0.4	0.2
Nickel	umol/g	0.2	0.3	<	0.3	<	0.5	<	0.4	0.2	0.2	0.8	0.2	<	0.2	0.1	0.6	0.5	0.5	0.6	0.5	0.5	0.5
Zinc	umol/g	0.1	1.1	1.5	0.8	1.1	1.6	0.6	1.4	42.6	67.7	110.3	53.4	36.6	27.6	23.6	8.6	25.0	17.8	7.7	5.8	11.0	7.4
Sum of SEM[2] (Cd/Cu/Ni/Pb/Zn)			3.1	3.6	2.4	3.0	4.8	1.7	4.2	64.0	106.1	184.9	86.6	58.3	42.4	36.6	15.0	36.0	25.1	14.7	10.6	17.5	12.7
AV Sulphide		0.1	15.5	116.0	43.0	2.0	5.0	1.7	<	5.1	9.2	<0.1	14.4	4.4	13.2	<0.1	<0.1	1.0	<0.1	3.8	4.5	5.8	25.7
SEM/AVS Ratio			0.20	0.03	0.06	1.52	0.97	1.00	>4.2	12.5	11.5	>185	6.0	13.3	3.2	>37	>15	36.0	>25	3.9	2.4	3.0	0.5

[1] MDL - Method detection limit - lowest level the parameter can be detected with confidence

[2] Sum of SEM - values may be higher than those for total metals because of dry/wet weight conversion factors.

Grain size differed between the exposure and reference lakes. The substrate type in the reference lake was predominately comprised of sand, whereas substrate type in the exposure lake was predominately silt (Table 4.5). Munsell colour of these sediments also differed, whereby reference sediments were very dark brown (VDKBR), and exposed sediments comprised different shades of olive. Bulk densities in these sediments were lowest in the reference lake and highest at the near-field stations and the corresponding percent moisture was considerably higher in the reference lake compared to the exposure lake. The Eh measurements were positive for all stations, indicating that the sediments were not anoxic.

Partial Metal Concentrations

Partial metal extractions may provide a relative measure of interstitial metal concentrations and are often used to predict sediment toxicity. Consequently, these measurements may provide an indication of the bioavailability of metals and may reflect biological responses better than total metal concentrations.

Partial metal results for near-field, far-field and reference areas are provided in Table 4.6 and selected metals (lead, arsenic, cadmium, copper, nickel, zinc) are illustrated in Figure 4.3. Of the total metals that exceeded CISQV (e.g., arsenic, cadmium, copper, nickel, lead, zinc), only concentrations of lead and zinc by partial extraction exceeded PEL values (Figure 4.3). Decreasing concentrations of partial metals with increased distance from the mine site were observed for cadmium, copper and zinc; no trends were observed for the partial extraction concentrations of the other metals. Partial metal concentration of arsenic and silver were below detection limits.

Analysis of hidden duplicate sediment samples showed good reproducibility for partial metal extraction values. Concentrations differed by only 0 to 9% between duplicate samples.

Acid Volatile Sulphide (AVS) and Simultaneously Extracted Metals (SEM)

In general, SEM/AVS ratios <1 may reflect non-toxic sediment conditions because some of the key metals (e.g., Ni, Pb, Cu, Cd, Zn) which are often associated with sediment toxicity will be in sulphide forms which reduces their bioavailability. However, it is possible that sediments with SEM/AVS ratios <1 will still be toxic due to the presence of

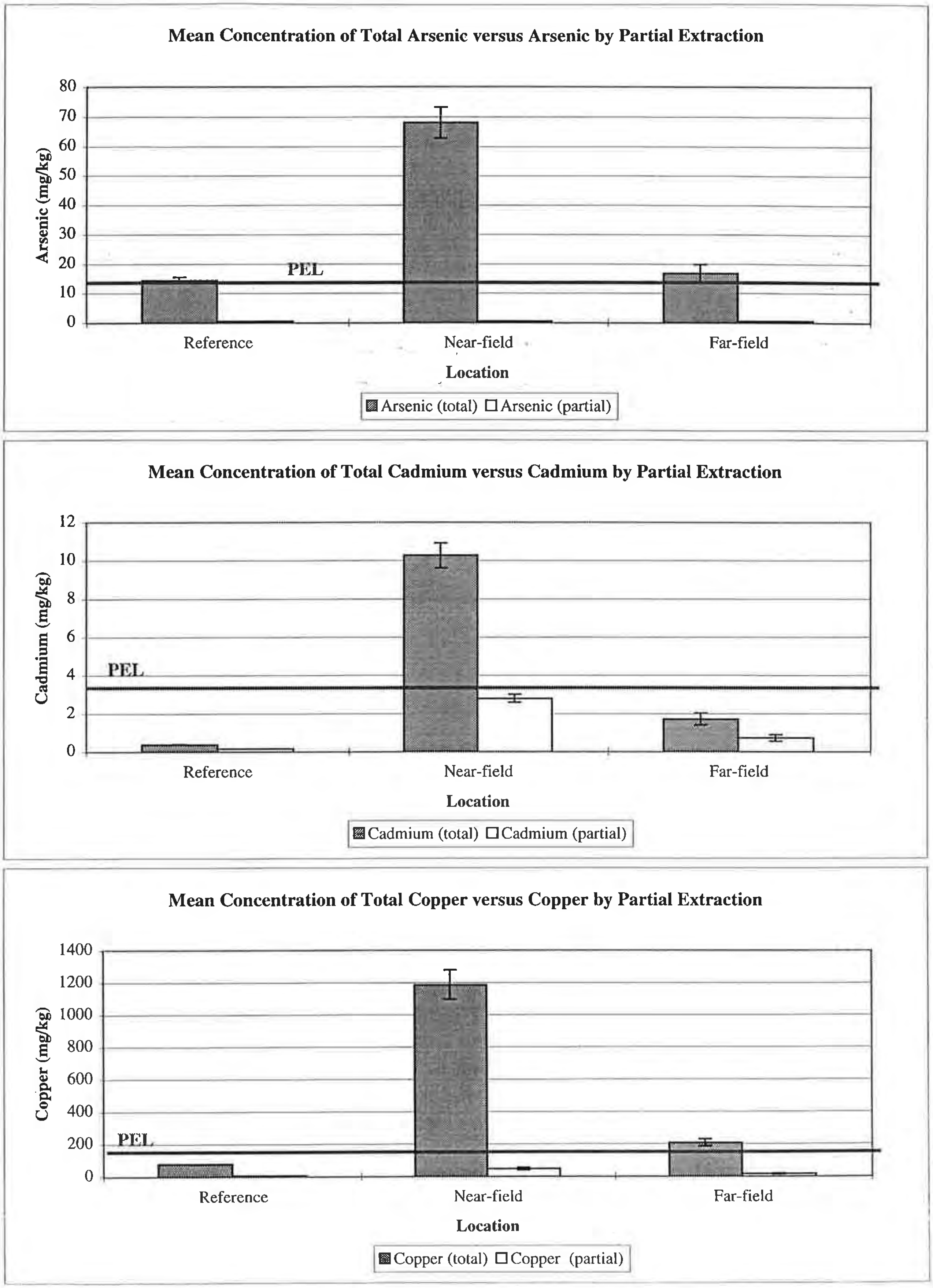
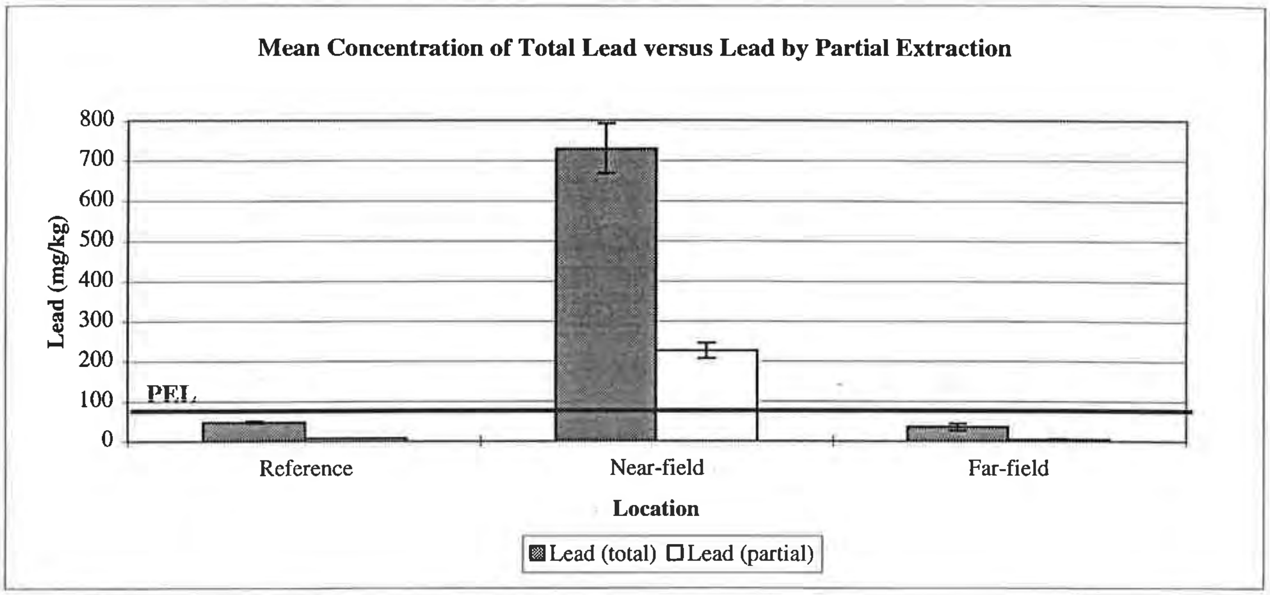
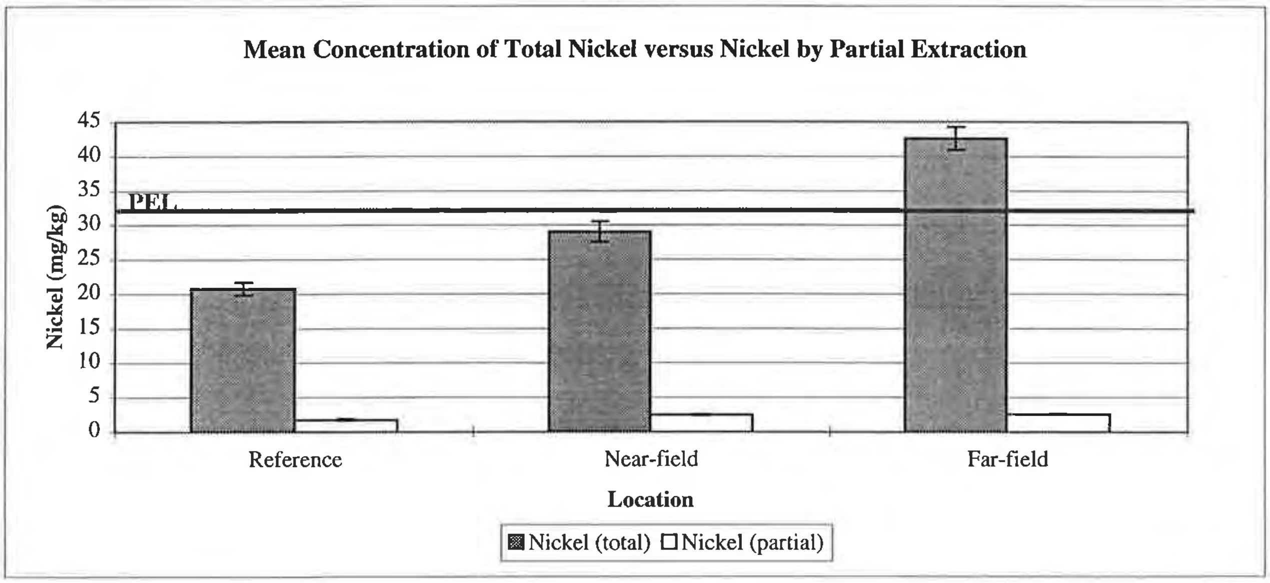


Figure 4.3: Mean Total and Partial Metals Concentrations in Sediments from Three Lake Areas. Myra Falls, September 1997.
Area Means (± 1 S.E.) Based on Data in Tables 4.5 and 4.6.





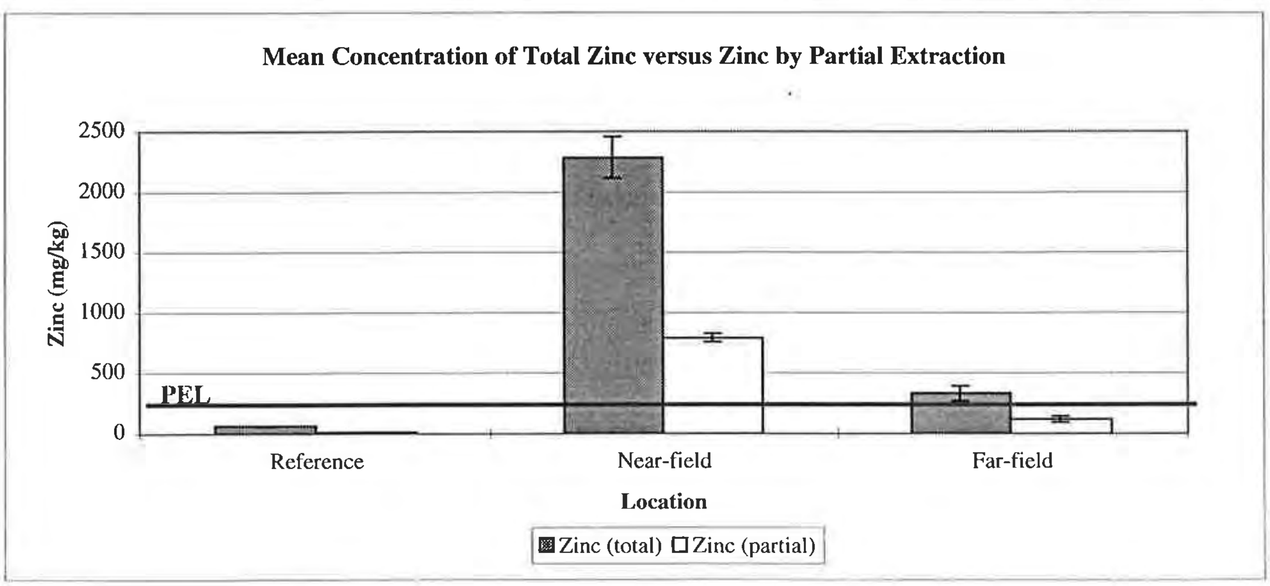


Figure 4.3: Mean Total and Partial Metals Concentrations in Sediments from Three Lake Areas. Myra Falls, September 1997.
Area Means (± 1 S.E.) Based on Data in Tables 4.5 and 4.6.

other metals (e.g., arsenic, mercury) or toxicants which are not included in the SEM analysis.

SEM/AVS ratios >1 often reflect sediments that may be toxic because there is insufficient sulphide to react with the bioavailable metals to make them less toxic. Again, SEM/AVS ratios >1 do not always accurately predict that sediments will be toxic because other factors, such as organic material or clay, will also bind metals, thereby reducing their toxicity.

The SEM/AVS ratio was developed to predict acute sediment toxicity and not necessarily for predicting chronic effects, including effects on the benthic community. However, it is not unreasonable to expect that, if sediments are acutely toxic, there would be some change in the benthic community structure that reflects this toxicity. Therefore, there may be a correlation between SEM/AVS ratios >1 and effects observed on benthic communities. This correlation is investigated in this report.

SEM/AVS ratios calculated for sediment samples collected from the near-field, far-field and reference areas are provided in Table 4.7. A comparison of the average ratio between each area is provided in Figure 4.4. Ratios for the near-field stations were generally higher than those for the far-field and reference stations. A decreasing trend in the ratios was observed with increased distance from the mine site. Consequently, interstitial metal concentrations and possibly acute sediment toxicity would be expected to be higher in the exposure area than in the reference area and higher in the near-field area compared to the far-field area. The ratios suggest that there may be acute sediment toxicity at all of the exposure stations, with the exception of far-field Station MF7 and there should be no acute toxicity at the reference stations.

Analysis of hidden duplicate sediment samples collected at two stations indicated the potential for high variability in SEM/AVS ratios. For example, duplicate SEM/AVS ratios at MF2-S differed by 55%. In contrast, ratios calculated at MN9-S differed by 3% (Table A2.6, Appendix 2).

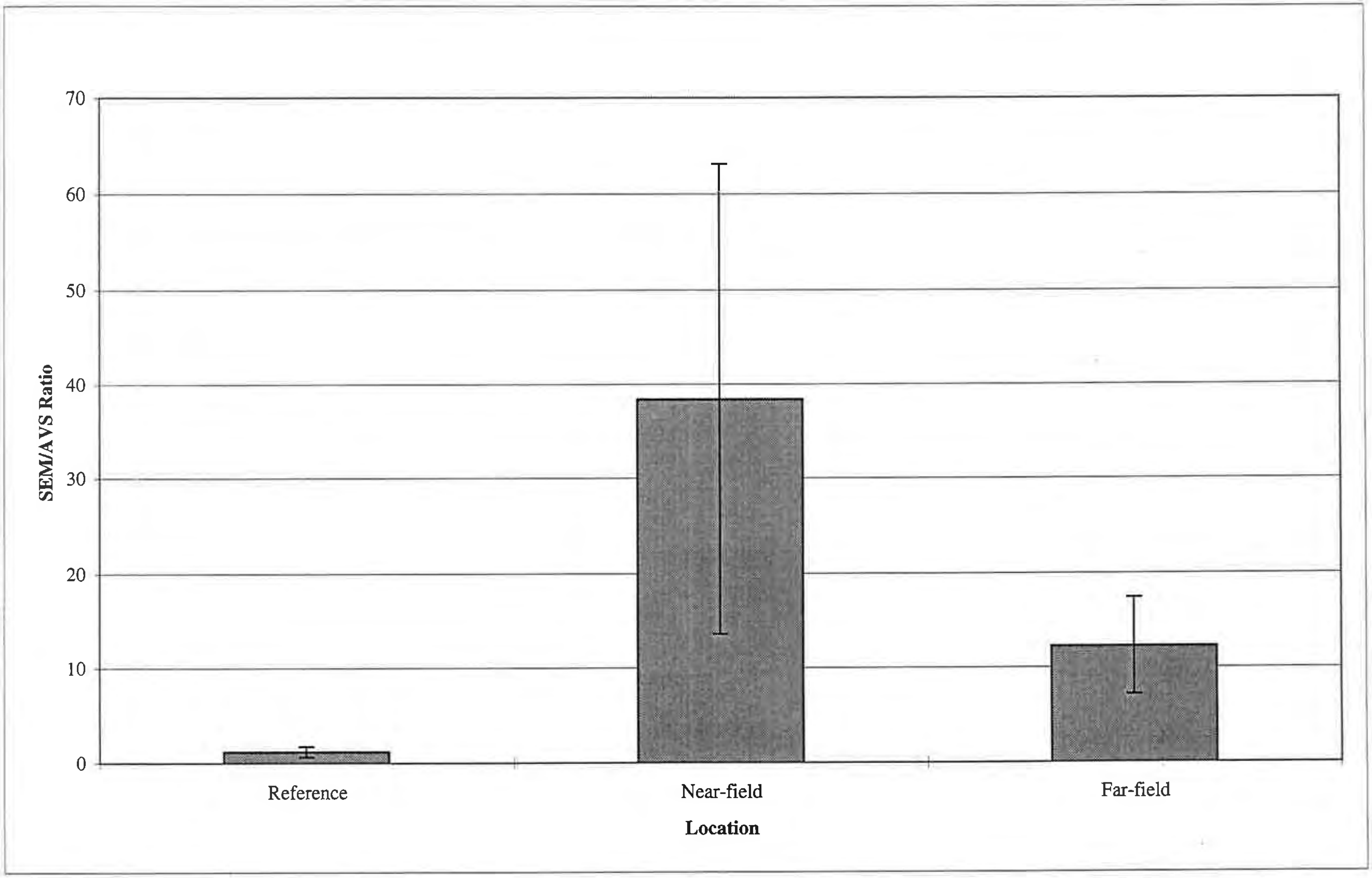


Figure 4.4: Mean SEM/AVS Molar Concentration Ratio by Lake Area (SEM values for Cd, Cu, Ni, Pb and Zn). Myra Falls, September 1997.
Area Means (± 1 S.E.) Based on Data in Table 4.7.

Aqua Regia versus Nitric Acid/Hydrogen Peroxide Extraction Methods

Two samples (MN4 and MF4) were analyzed for total metals after extraction by *aqua regia* to compare with the results of total metals obtained by nitric acid and hydrogen peroxide extraction (Appendix 2).

There was very little variation in the concentrations of metals between the two methods. The differences between the two sets of data were generally less than 10% for the key metals (i.e., Cd, Cr, Cu, Pb, Mg, Ni, Ag and Zn).

Sediment Toxicity

Toxicity tests were conducted on sediment samples collected from the lake sites only. Sediment toxicity test results for *Chironomus*, *Hyalella* and *Tubifex* are provided in Table 4.8 and mean values for each area are shown in Figure 4.5.

The *Tubifex* test was not a sensitive test for acute toxicity (100 % survival was observed in sediment collected from all sites sampled), however, this is not surprising since the test was developed to measure sublethal effects (i.e., reproduction). Percent survival of *Chironomus* and *Hyalella* was lowest at stations in the near-field area. *Hyalella* survival at the far-field area was still lower than at the reference area, whereas there was no difference in *Chironomus* survival between far-field and reference areas.

Mean weights of *Chironomus* and *Hyalella* were lowest for the near-field sediments. *Hyalella* weights were slightly higher at the far-field stations and highest at the reference stations. However, these data should be interpreted cautiously because at some of the sites toxicity was acute (up to 100% mortality) and the mean weight may be based on only a few surviving animals. No typical mine-related trend in *Chironomus* weights between far-field and reference areas was observed. *Chironomus* weights were notably higher for sediments from the far-field area compared to the response to sediments from the reference and near-field areas. Again, these data need to be interpreted cautiously because of the high level of organism mortality.

Mean number of young and cocoons produced by *Tubifex* did not differ between near-field and far-field areas and were slightly higher in the reference area.

Table 4.8: Sediment Toxicity Results, Myra Falls, September 1997

Station	*Chironomus riparius*		*Hyalella azteca*		*Tubifex tubifex*	
	Survival ± S.D. (%)	Mean Dry Weight/Organism ± S.D. (mg)	Survival ± S.D. (%)	Mean Dry Weight/Organism ± S.D. (mg)	Survival ± S.D. (%)	Mean Young Produced per Adult
MR1	62 ± 4	0.67 ± 0.08	82 ± 4	0.28 ± 0.09	100	23 ± 2
MR2	52 ± 4	0.66 ± 0.05	70 ± 7	0.26 ± 0.02	100	25 ± 2
MR3	58 ± 4	0.64 ± 0.08	80 ± 0	0.17 ± 0.03	100	23 ± 2
MR4	84 ± 15	0.76 ± 0.28	50 ± 0	0.22 ± 0.02	100	28 ± 5
MR5	58 ± 8	0.57 ± 0.09	74 ± 6	0.21 ± 0.02	100	25 ± 2
MR6	28 ± 4	0.56 ± 0.04	56 ± 6	0.17 ± 0.02	100	30 ± 6
MR7	72 ± 8	0.73 ± 0.36	62 ± 4	0.19 ± 0.02	95 ± 11	21 ± 4
MN4	0	-	0	-	100	18 ± 6
MN5	0	-	6 ± 13	0.17	100	22 ± 2
MN6	0	-	4 ± 6	0.12 ± 0.08	100	21 ± 1
MN7	2 ± 4	0.49	2 ± 4	0.04	100	11 ± 3
MN8	0	-	0	-	90 ± 14	18 ± 2
MN9	2 ± 4	0.50	0	-	100	23 ± 5
MN10	2 ± 4	0.52	8 ± 11	0.06 ± 0.05	100	20 ± 4
MF1	64 ± 6	1.24 ± 0.18	50 ± 7	0.07 ± 0.02	100	17 ± 5
MF2	60 ± 10	1.13 ± 0.16	20 ± 0	0.08 ± 0.05	100	16 ± 3
MF3	68 ± 4	1.06 ± 0.12	62 ± 4	0.11 ± 0.04	100	21 ± 3
MF4	62 ± 4	1.11 ± 0.16	62 ± 4	0.13 ± 0.02	95 ± 11	23 ± 4
MF5	54 ± 6	1.09 ± 0.17	68 ± 4	0.11 ± 0.01	100	17 ± 4
MF6	60 ± 19	1.05 ± 0.18	24 ± 15	0.16 ± 0.05	100	20 ± 2
MF7	52 ± 8	1.31 ± 0.24	72 ± 4	0.18 ± 0.05	100	17 ± 3

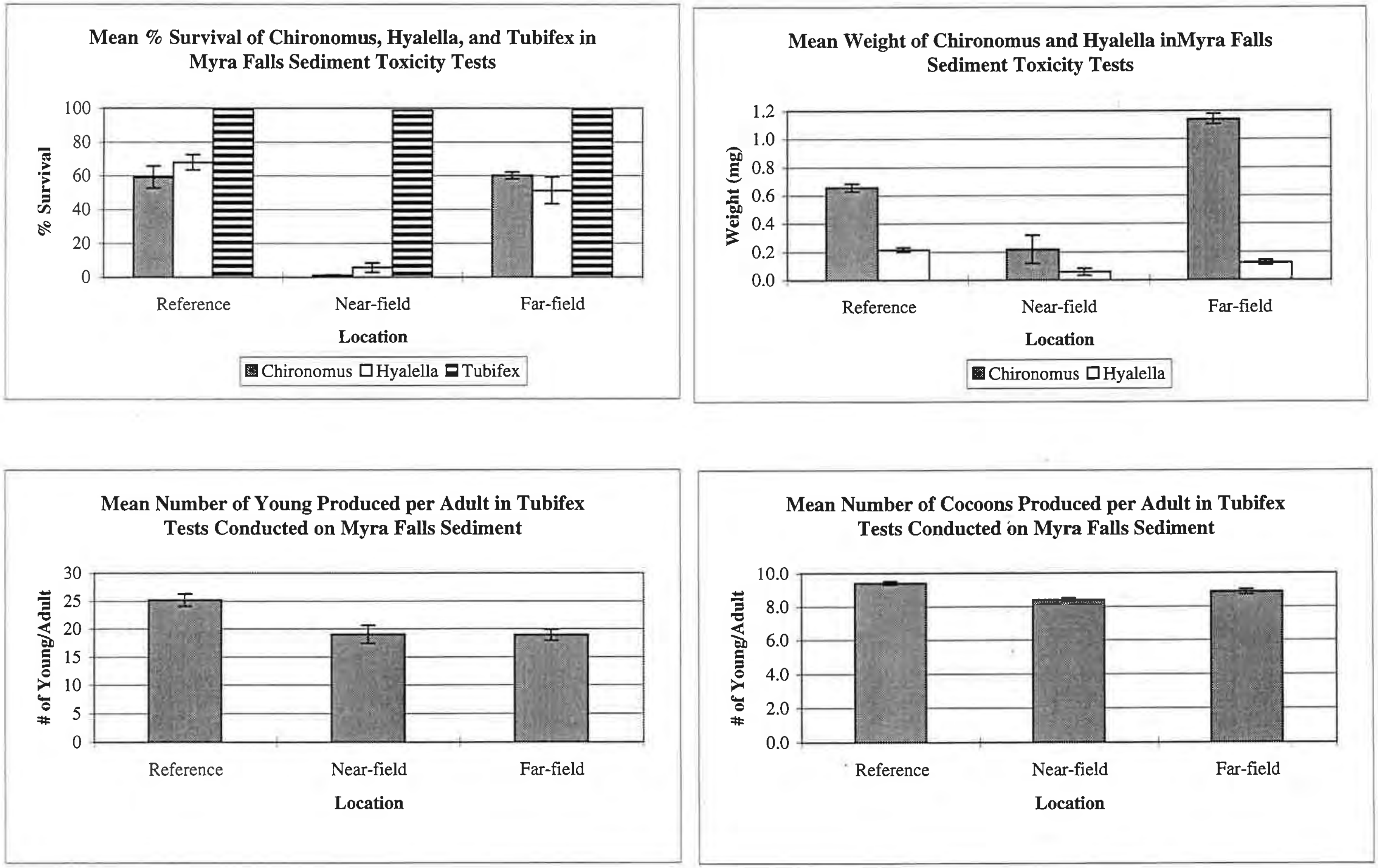


Figure 4.5: Mean Sediment Toxicity Test Results (± 1 S.E.), Myra Falls, September 1997.

4.4 Benthic Invertebrates

Benthic invertebrate data are provided in Tables A6.1 and A6.2, Appendix 6. All associated QA/QC data are provided in Appendix 2, Table A2.1.

Myra Creek

In Myra Creek, mean benthic invertebrate density, number of taxa, and EPT index values were all slightly lower in the exposure area compared to the reference area (Table 4.9, Figure 4.6). Percent chironomids was slightly higher in the exposure area compared to the reference area. Mean EPT index values and percent chironomids best separated reference from exposure communities and the trends were consistent with typical mine effects.

Buttle and Brewster Lakes

Mean benthic invertebrate data for the near-field, far-field and reference areas are illustrated in Figure 4.7 and provided in Table 4.9. Mean benthic invertebrate density was highest in the reference area and lowest in the far-field area. Mean number of taxa and mean percent chironomids did not differ among the three lake areas. Although there was no change in the number of taxa, indicator taxa known to be sensitive to metal contamination (e.g., harpacticoids, *Pisidium*) were absent from the exposure area and common in the reference area. Although there were habitat differences (e.g., grain size, TOC content) between the reference and exposure lakes, these differences would not prevent colonization of the exposure lake by these two groups of organisms. However, the absence of these organisms in Buttle Lake may be due to natural seasonal differences. In the reconnaissance survey, *Pisidium* and harpacticoids were found at a couple of the sites sampled (Appendix 1).

Chironomid Deformities

There were no trends in chironomid mentum and mandible deformities between reference and exposure areas. The occurrence of deformities was low in all areas, even at the near-field stations where sediment contamination was quite high.

Table 4.9: Benthic Community Indices for Myra Creek and Buttle and Brewster Lakes, Myra Falls, September 1997.

Lake Stations

Station	Number of Taxa	Number of Individuals[1]	Chironomids (%)	Number of Harpacticoids	Number of Pisidium
MR1	14	224	49.11	26	12
MR2	12	192	48.96	26	4
MR3	5	172	54.65	24	10
MR4	8	180	44.44	38	8
MR5	7	266	30.83	48	6
MR6	7	120	51.67	20	4
MR7	8	162	59.26	24	0
MN4	9	43	46.51	1	0
MN5	17	108	42.59	0	0
MN6	9	154	64.94	0	0
MN7	8	124	43.55	0	0
MN8	7	127	52.76	0	0
MN9	8	230	37.39	0	0
MN10	9	190	22.11	0	0
MF1	9	64	43.75	0	0
MF2	10	72	72.22	0	0
MF3	16	130	49.23	0	0
MF4	9	110	32.73	0	0
MF5	7	96	31.25	0	0
MF6	6	136	36.76	0	0
MF7	7	146	46.58	0	0

Creek Stations

Station	Number of Taxa	Number of Individuals[2]	EPT Index	Chironomids (%)	Ephemerellidae (%)	Orthocladius + Cricotopus (%)
MCR1	27	288	14	5.2	10.76	0.00
MCR2	27	136	15	7.4	8.82	0.00
MCR3	45	831	20	21.2	6.02	2.89
MCR4	42	665	22	7.8	5.71	0.75
MCR5	32	152	13	11.2	5.92	0.00
MCR6	30	273	13	17.2	0.73	0.00
MCR7	15	38	7	13.2	0.00	0.00
MCR8	26	187	13	13.9	4.28	0.00
MCR9	32	274	13	22.6	1.46	0.00
MCR10	34	270	12	36.7	2.96	0.00
MCE1	25	154	8	16.2	0.00	6.49
MCE2	34	442	13	14.7	1.58	2.94
MCE3	22	90	9	16.7	2.22	6.67
MCE4	17	38	8	18.4	0.00	2.63
MCE5	20	101	6	32.7	0.99	5.94
MCE6	28	286	9	18.2	0.35	3.50
MCE7	36	336	12	30.1	0.30	2.38
MCE8	29	327	12	21.1	0.92	1.53
MCE9	25	173	6	24.3	0.00	1.73
MCE10	35	453	15	51.9	0.88	1.10

[1] Number of individuals per 0.11 m^2 composite of five Petite Ponar samples.

[2] Number of individuals per 0.5 m^2 composite of five T-samples.

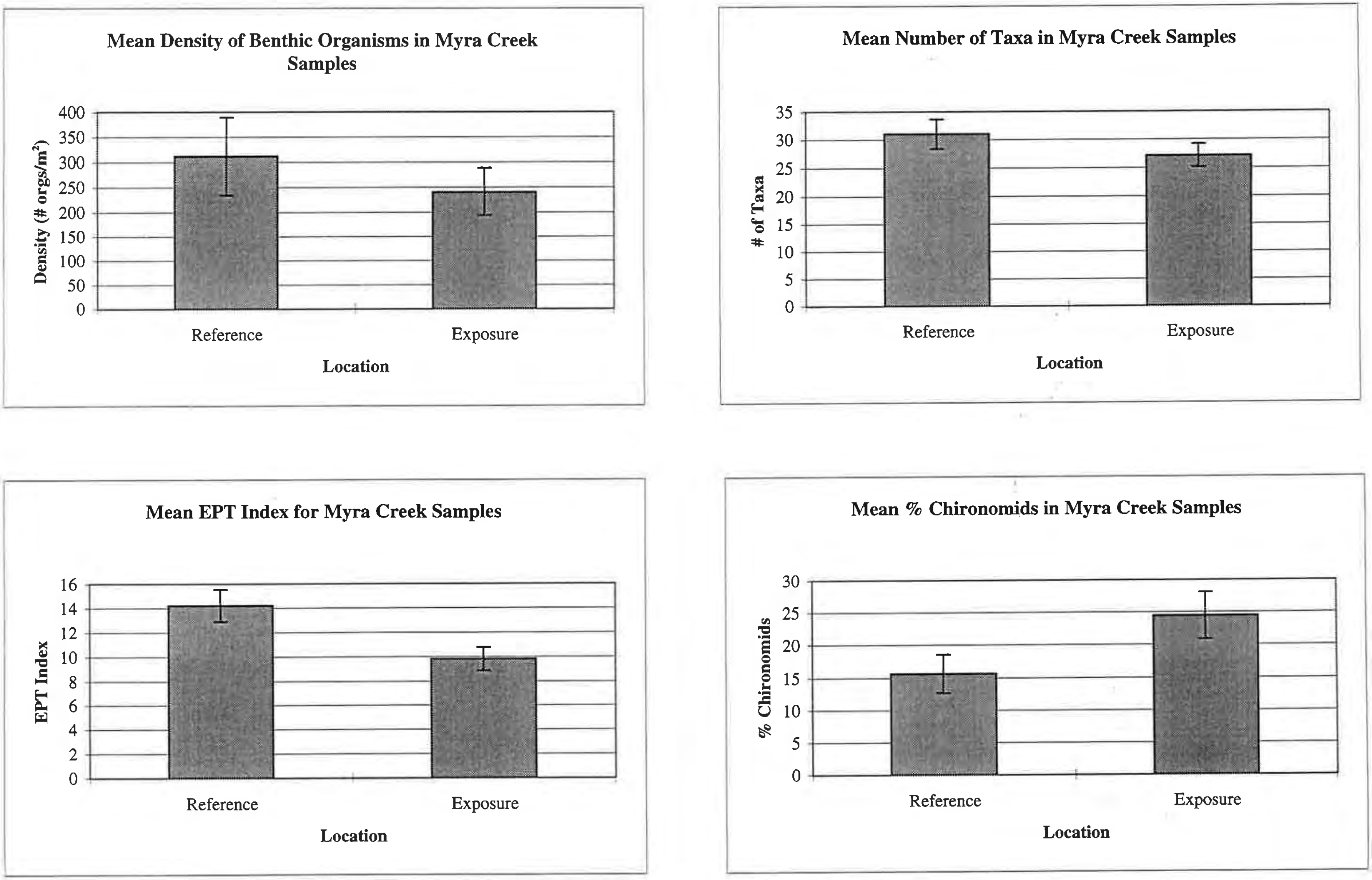
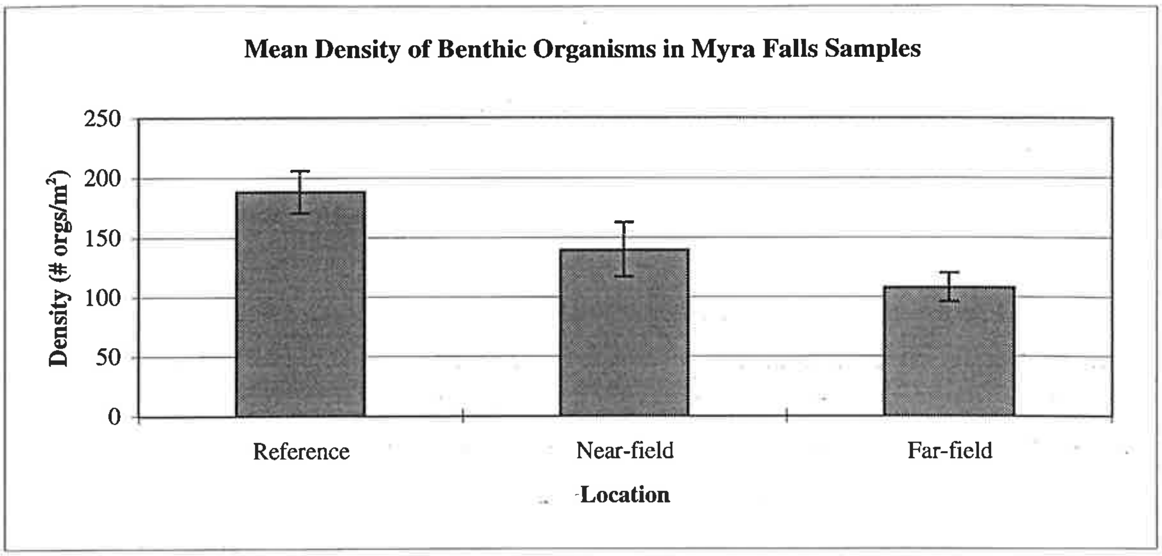
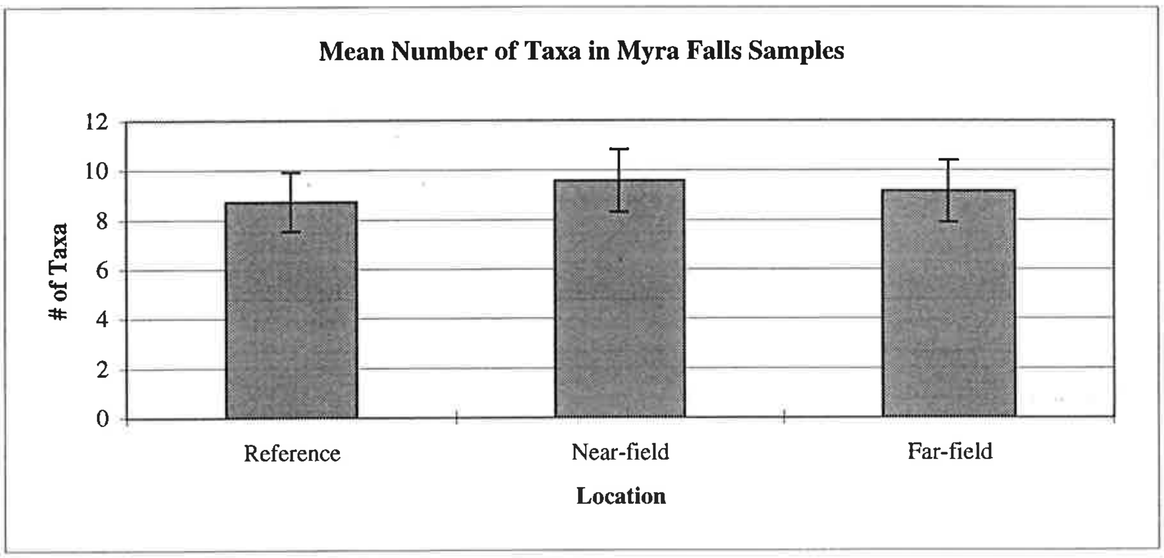


Figure 4.6: Mean Values for Selected Benthic Indices in Myra Creek. Myra Falls, September 1997.
Area Means (± 1 S.E.) Based on Data Presented in Table 4.9.





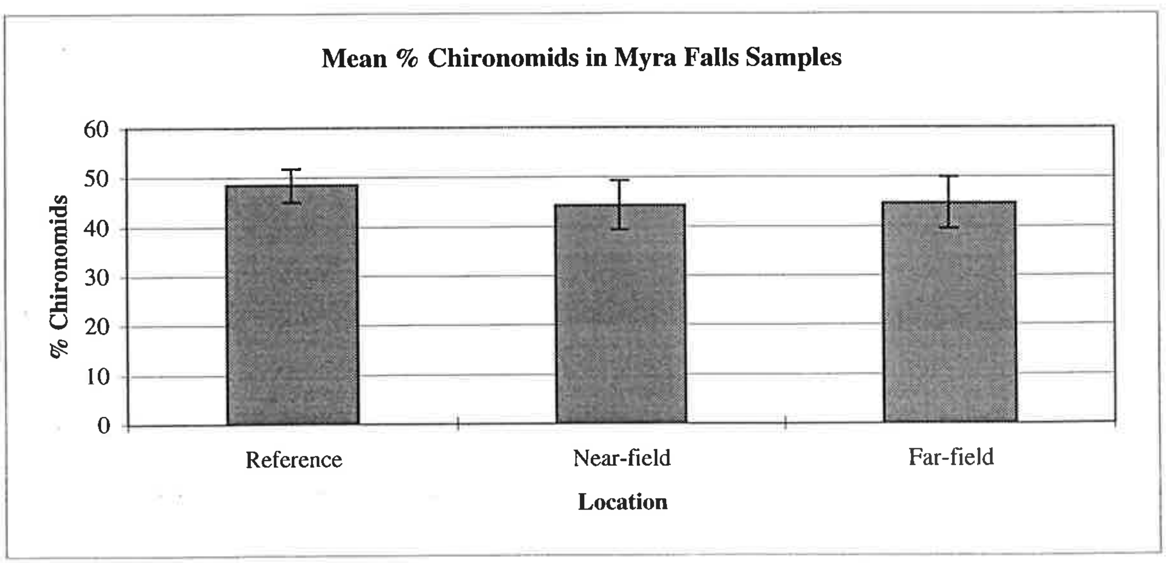


Figure 4.7: Mean Values for Selected Benthic Indices in Buttle Lake and Brewster Lake (reference) Myra Falls, September 1997.
Area Means (± 1 S.E.) Based on Data in Table 4.9.

5.0 HYPOTHESIS TESTING

5.1 Methods

The four hypotheses considered testable at Myra Falls, including the two examined qualitatively (i.e., H9, H13) and the sediment quality triad are listed in Table 5.1. The table also provides a more specific listing of the "effect" (response) and "exposure" (predictor) variables examined under each hypothesis. The general criterion behind all of these hypotheses is that a mine "effect" is a measurable difference between reference and exposure locations, and/or a trend between locations that are exposed to different degrees. Throughout this document, the term "significant" is used when a statistical test was performed and the level of significance was $p<0.05$.

The hypotheses address either the ability of a particular monitoring tool to detect such an effect (and, in aggregate, whether an effect exists) (e.g., H5 to H8), or the **relative** ability of two different monitoring tools to detect such an effect (e.g., H1). H9 through H12 address the **relative** ability of two monitoring tools to detect a correlation between specific exposure and response variables (effect), while H13 addresses the ability of a particular toxicity testing tool to show such a correlation.

These different types of hypotheses require different methods of statistical analysis. The following subsections describe the statistical approach needed for each category. In all cases, appropriate data transformations were applied prior to statistical analysis, such as log transformation for chemical concentrations, or other parameters that span a wide range, and arcsine square-root transformations for percent response variables. A significance criterion was used for all the statistical analyses, and use of the term 'significant" implies that this criterion was met.

It should be recognized that the term "predictor" variable is not intended to mean that the measure of exposure used (e.g., metal concentration in water) can be used to "predict" a specific biological response at all mine sites or in other surveys at this mine site. Nor does it imply that the predictor is necessarily the cause of a biological effect. Rather, the predictive ability is only suggested by correlation between effect and exposure measures.

TABLE 5.1: VARIABLES AND HYPOTHESES AT MYRA FALLS

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis	Comment
H1	Sediment Toxicity Response i (Tool 1) Sediment Toxicity Response j (Tool 2)	Lake Number (in order of increasing distance from mine)	no lake x tool interaction by ANOVA	Amphipod, chironomid mortality. *Tubifex* survival reproduction response.
H6	Indicator Taxa Benthic Density No. of Taxa EPT[1] Index	Lake or Creek Number (in order of increasing distance from mine)	no among lake or creek difference by ANOVA	Collections at several stations per area.
H9*	Indicator Taxa Benthic Density No. of Taxa EPT Index	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2)	same Y-X correlations with Tool 1 as Tool 2	Could use other benthic indices if desired. Not tested statistically because of only one exposure level.
H10	Benthic Density No. of Taxa Sediment Toxicity Response I	Partial Metal i in Sediment (Tool 1) Total Metal i in Sediment (Tool 2) SEM/AVS[2] ratio (Tool 1)[2] SEM Molar Sum (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	Fractions from partial extraction. SEM based on Cu, Zn, Ni, Cd and Pb.
H11	Benthic Density No. of Taxa	Sediment Toxicity Response i (Tool 1) Sediment Toxicity Response j (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	Use various toxicity endpoints (*Hyalella, Chironomus, Tubifex* tests).
H13*	Benthic Density No. of Taxa EPT Index	Predicted % Response in Exposure Reach	no Y-X correlation	Not tested statistically, due to only one exposure reach in potential toxicity gradient *in situ*.
Other Triad Hypotheses	Benthic PCs Sediment Toxicity PCs Sediment Chemistry PCs	Benthic Variables (B) Toxicity Variables (T) Chemistry Variables (C)	no correlation C-B, C-T and B-T	Mantel's test and/or multiple correlation Sphericity test of overall correlation (triad)

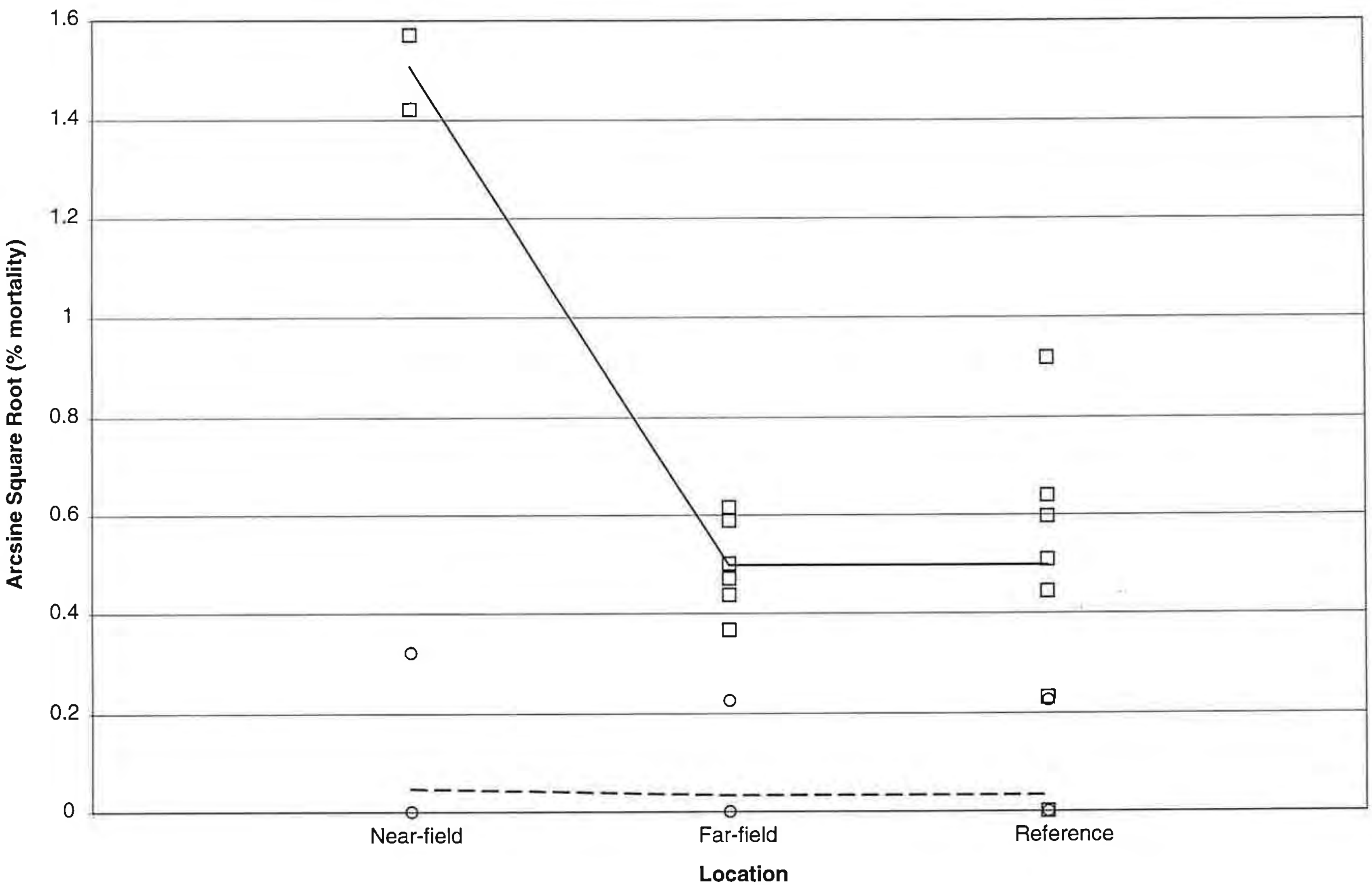
[1] EPT = Ephemeroptera, Plecoptera, Trichoptera.
[2] SEM = Simultaneously Extracted Metal.
AVS = Acid-volatile Sulphide.
* H9 and H13 examined qualitatively.

5.1.1 H1 - Comparison of Sediment Toxicity Tests

Hypothesis H1 addresses the **relative** ability of three sediment toxicity test tools (response measures) to detect a mine effect. In particular, the *Hyalella azteca*, *Chironomus riparius* and *Tubifex tubifex* tests were compared to determine whether these tools differ in their ability to detect a mine effect (i.e., a reference versus exposure area difference, or a trend with degree of exposure within the exposure area - near-field response different than far field). An area identifier, ordered within the exposure area to reflect distance from the mine site (i.e., near-field and far-field lake areas), was used as a surrogate for degree of exposure to mine-related contaminants. It is reasonable to assume that with increased distance there will be an attenuation in contaminant levels. The use of direct measures of exposure in evaluating sediment toxicity test results is included within the context of the overall Sediment Quality Triad hypothesis (Section 5.1.5). Analysis of variance (ANOVA) was used to address this hypothesis, as described below.

In general, ANOVA partitions the overall variance in the response measure (mine effect) into various terms representing effects of particular interest. In the case of Myra Falls, with only one creek reference area and one creek exposure area, and one lake reference area and two exposure areas, there is limited opportunity for partitioning of "among area" effects. In order to determine whether two toxicity testing tools differ in their ability to detect mine effects at Myra Falls, a simple ANOVA was used to determine whether there was a significant area x tool interaction (i.e., two tools showing different patterns of response with exposure level). If there was, then an examination of a plot of the interaction, such as Figure 5.1 or Figure 5.2, was undertaken to confirm that the pattern was consistent with one toxicity tool being a better indicator of mine effects.

For example, in Figure 5.1, *Hyalella* mortality in sediments (Tool 1) gives a response that decreases with degree of exposure, from near field to far field, while *Tubifex* mortality (Tool 2) does not respond with degree of exposure. This produces a significant area x tool interaction in the ANOVA, and indicates that *Hyalella* mortality was a superior tool in demonstrating a mine effect. In Figure 5.2, *Hyalella* mortality (Tool 1) distinguishes near-field from far-field areas, whereas *Chironomus* mortality (Tool 2) only distinguishes exposure from reference areas. This produces a significant area x tool interaction in the ANOVA, because the tools have different response patterns, but does not indicate that either tool was superior.



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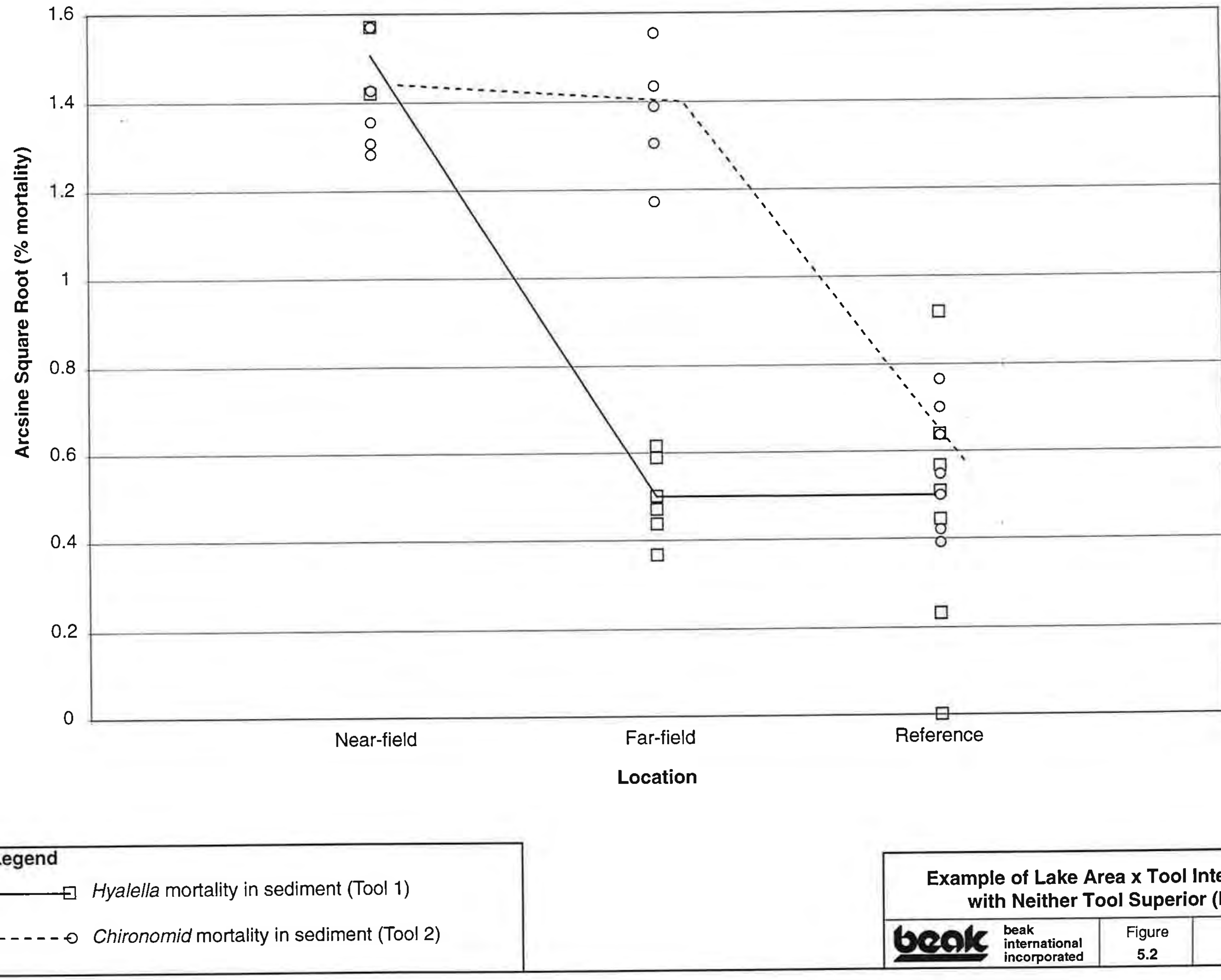
Hyalella mortality in sediment (Tool 1)

Tubifex mortality in sediment (Tool 2)

Examples of Lake Area x Tool Interaction with Tool 1 Superior (H1)

beak international incorporated	Figure 5.1	April 1998



Example of Lake Area x Tool Interaction with Neither Tool Superior (H1)

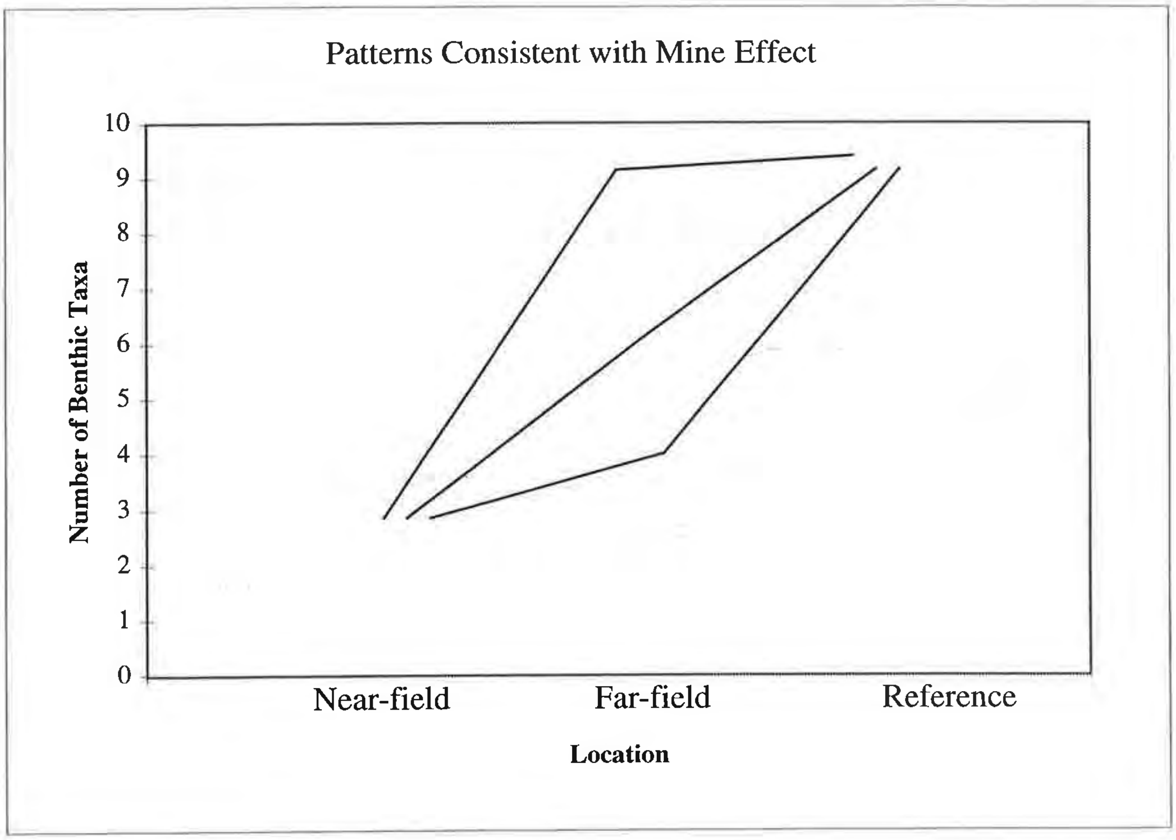
beak international incorporated	Figure 5.2	April 1998

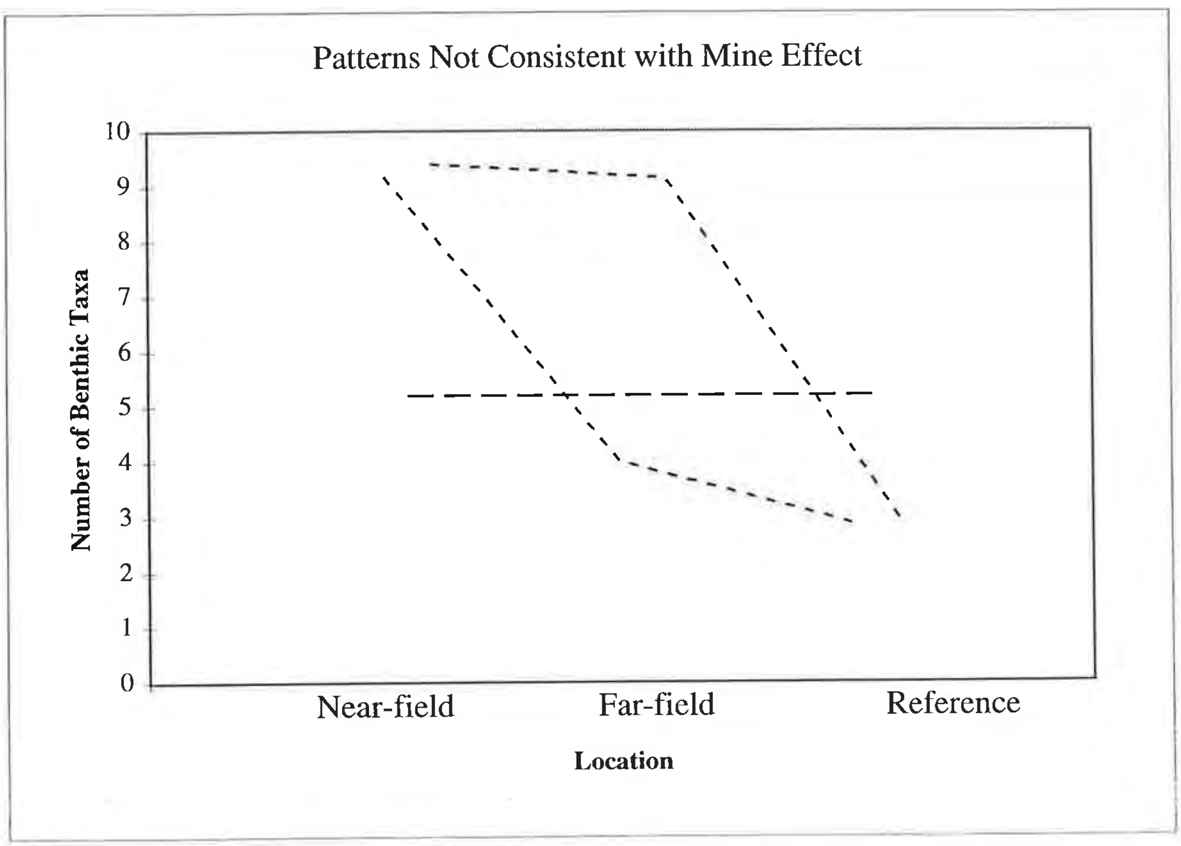
5.1.2 H6 - Benthic Community Structure Response to Exposure

Hypothesis H6 addresses the ability of a particular benthic index tool (response measure) to detect a mine effect. For example, in H6, numbers of benthic taxa were compared across areas to determine whether this tool demonstrates a mine effect (i.e., a reference versus exposure area difference, or a trend with degree of exposure within the exposure area). However, the overall objective of testing H6 was to determine if benthic invertebrate community assessments are useful in determining mine effects when using a suite of metrics rather than testing specifically whether or not a particular metric was useful. An area identifier, ordered within the exposure zone to reflect distance from the mine site (i.e., near-field and far-field lake areas), was used as a surrogate for degree of exposure to mine discharges. ANOVA was used to address this hypothesis, as described below.

In general, ANOVA partitions the overall variance in the response measure into a number of terms representing effects of particular interest. In the case of Myra Falls, with only one reference area in each habitat type (creek or lake), and one or two exposure areas, there was limited opportunity for partitioning of "among-area" effects. In order to determine whether a benthic index tool could detect a mine effect, a simple test by ANOVA was used to determine whether the index varies more among areas than it does within areas. If so, then an examination of the pattern of differences between areas was undertaken to confirm that the pattern of response with exposure level was consistent with a mine effect.

For example, in Figure 5.3, the top graph illustrates a number of response patterns that are consistent with a toxic mine effect (i.e., decreasing numbers of benthic taxa near the mine). The bottom graph illustrates a number of response patterns that are not typically consistent with a mine effect (i.e., greater numbers of taxa near the mine, or no trend with mine proximity). Professional judgement is always needed for interpretation of intermediate response patterns. For example, the bottom graph may represent a mine effect if a mine discharge, instead of having a toxic effect, was resulting in nutrient enrichment of an oligotrophic environment which would lead to more benthic invertebrate taxa.





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————	patterns consistent with mine effect
- - - - - - -	patterns not consistent with mine effect
— — — —	no pattern (no difference among areas)

Examples of Response Patterns Consistent (or not) with Mine Effects (H6)

beak international incorporated	Figure 5.3	April 1998

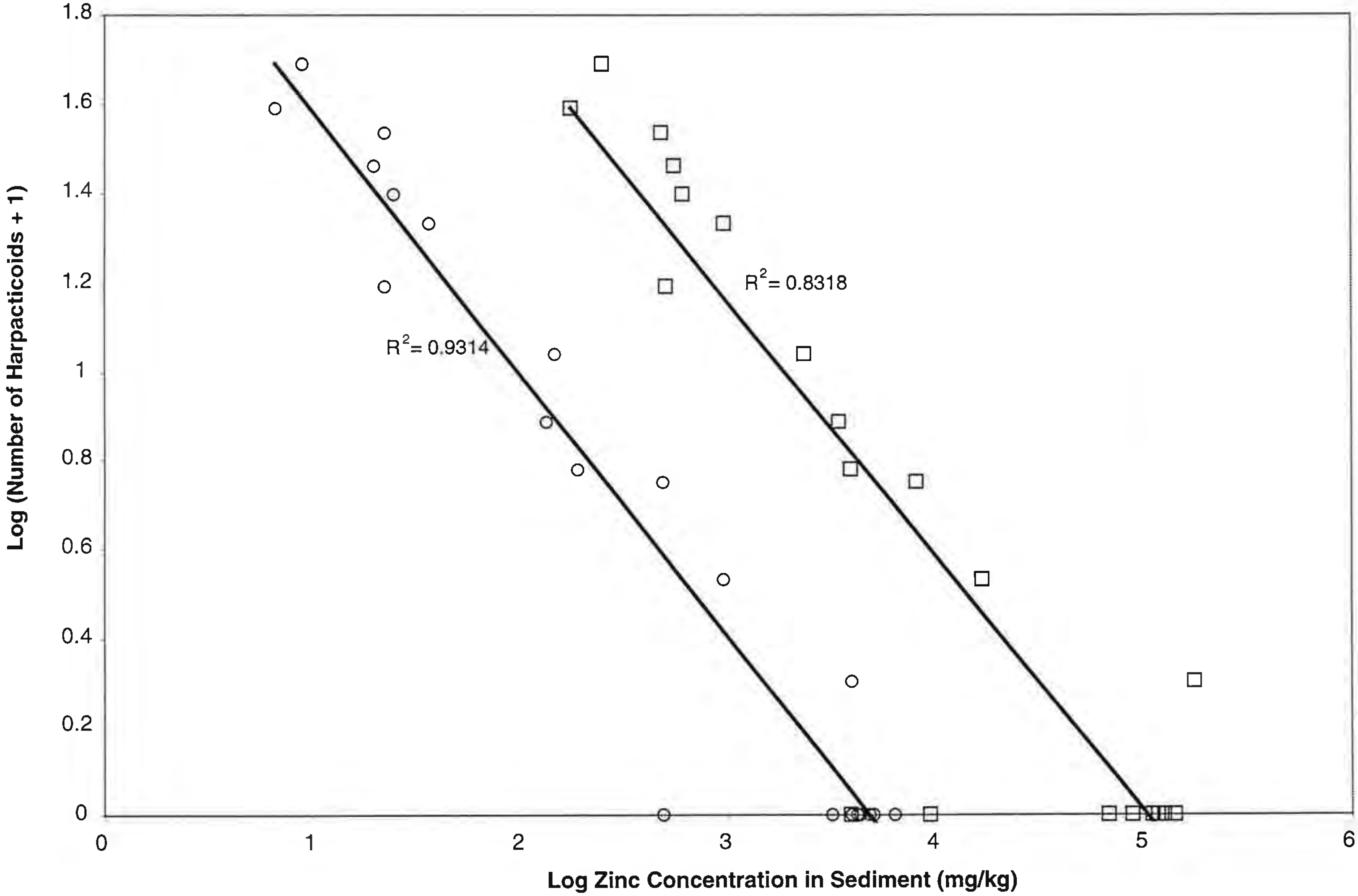
5.1.3 H9 through H11 - Tool Integration Hypotheses

Hypotheses H9, H10 and H11 address the **relative** ability of two monitoring tools to detect a mine effect. For example, in H9 (not formally tested at Myra Falls because of the lack of a water chemistry gradient in the creek and lake) dissolved metal in water would be compared to total metal in water, for each of the key metals, to determine whether these two monitoring tools differ in their ability to detect a mine effect (i.e., a correlation between a biological response measure, such as number of taxa, and the metal predictor variable). Correlation analysis was used to address this hypothesis, as described below.

The squared coefficient of correlation (r^2) between the response measure (Y) and each predictor variable (X1 or X2) indicates the proportion of variance in the response measure that is explained by the predictor (i.e., by the corresponding line in Figure 5.4). The best predictor, for each pair compared, is the one which explains the highest proportion of variance (i.e., has the highest r^2 and hence the highest r). No statistical test was performed to determine whether r_1 differs significantly from r_2, since the two r values are based on the same Y data set and are not independent. However, the individual r values were tested for statistical significance. Two r values were compared, to draw inferences about which monitoring tool is better, only when at least one of the r values was of the correct sign (negative or positive) to suggest a mine effect, and statistically distinguishable from zero based on a one-tailed test.

At Myra Falls, the degree of significance for H10 and H11 may be somewhat overstated, because the sampling stations are clustered in three areas (one reference and two exposure areas) and therefore may not be independent as assumed by the correlation test procedure. The clustering of stations in a few areas was necessary based on the limnological features of the study area as discussed in Section 2.1.2.

When differences between r values are small (e.g., ≤ 0.1), even though one or both r values may be statistically significant, a judgement is generally not made that the tool with the slightly higher r value is better able to detect an effect. Also, the correlations are generally calculated for many exposure measures (metals), so that judgements with respect to which exposure measure tool (e.g., total versus dissolved concentration in water) is more strongly correlated with biological response are made by the weight-of-evidence based on all r values for each tool. The exposure and response measures selected for inclusion in this analysis were those which showed an apparent spatial relationship to the



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□ Log Total Zinc in Sediment

○ Log Zinc by Partial Extraction in Sediment

Example of Approach to Testing H10 at Myra Falls

beak international incorporated	Figure 5.4	April 1998

mine site (i.e., trend among exposure areas or difference between reference and exposure areas).

Hypothesis H9 would have been tested in Myra Creek by correlation between benthic index values and metal concentrations from only two stream reaches (reference and exposure). This is a result of the simple CI design imposed by the lack of an obvious water chemistry gradient downstream of the mine. It was also found that there was no variability in the water chemistry data in the exposure area so it was not practical to formally test H9 at this site.

Hypothesis H10 was expanded here to test both benthic index versus sediment chemistry correlations and sediment toxicity versus sediment chemistry correlations, based on near-field, far-field and reference lake data. The sediment chemistry tools include total metal concentrations (hydrogen peroxide/nitric acid extraction), partial metal concentrations (hydroxylamine extraction) and the ratio of the molar sum of simultaneously extracted metals (SEM) and acid volatile sulphide (AVS). Metals included in the SEM value are Cd, Cu, Ni, Pb and Zn. These are metals often contributing to toxicity and potentially rendered non-bioavailable by the formation of metal monosulphides.

Hypothesis H11 examines the remaining component of the "sediment quality triad" - the correlation between benthic indices and sediment toxicity - based on near-field, far-field and reference lake data. The toxicity tests include amphipod (*Hyalella azteca*), chironomid (*Chironomus riparius*) and oligochaete (*Tubifex tubifex*) tests on sediment samples from each lake station.

5.1.4 H13 - Chronic Toxicity - Linkage with Benthic Results

Hypothesis H13 addresses the ability of a particular effluent toxicity testing tool to predict a mine effect that has been otherwise demonstrated (e.g., a benthic index response to exposure). For example, H13 might address whether a specific benthic response can be predicted from effluent toxicity to *Ceriodaphnia, Selenastrum*, fathead minnow or duckweed.

The CI design in Myra Creek prevents the determination of correlations between predicted water toxicity *in situ* and the benthic community response, because there is only one level of exposure downstream of the mine. That is, a correlation can only be tested if there are two or preferably more levels of exposure possible in the creek, in addition to the upstream reference. Also, because a significant fraction (more than half) of the metal loading to the creek is ascribed to seepages which are not tested for toxicity, it is not possible to predict the downstream water toxicity with confidence using effluent toxicity.

To assist in qualitative evaluation of the hypothesis, it is useful to recognize that the concentration of treated effluent from the tailings pond at Myra Creek exposure stations was about 15% during the September 1997 field survey, based on an average sulphate level of 586 mg/L in the effluent (mean value from four samples tested for toxicity), 88 mg/L in the Myra Creek exposure area, and an upstream concentration of <2 mg/L (from data presented in Section 3.0).

If it is considered that the effluent is the main source of sulphate and that seepage loadings of zinc (the main toxicant) are approximately equal to effluent loadings, then potential water toxicity in the exposure area can be inferred based on effluent toxicity. This involves finding the percent inhibition of the toxicity test endpoint (e.g., inhibition of fathead minnow growth) that corresponds to 30% effluent on the concentration-response function from the effluent toxicity test. Because there are four effluent samples (July, August, September, December) and four test types, a range of values is obtained for the predicted *in-situ* percent inhibition. Substantial toxicity (e.g., ≤15%), in conjunction with an observed biological impairment (e.g., reduced numbers of benthic taxa in the exposure area), would at least be consistent with an effluent toxicity contribution to the impairment. However, because a correlation analysis was not possible, such an effect could not be demonstrated at Myra Falls.

5.1.5 Triad Hypotheses

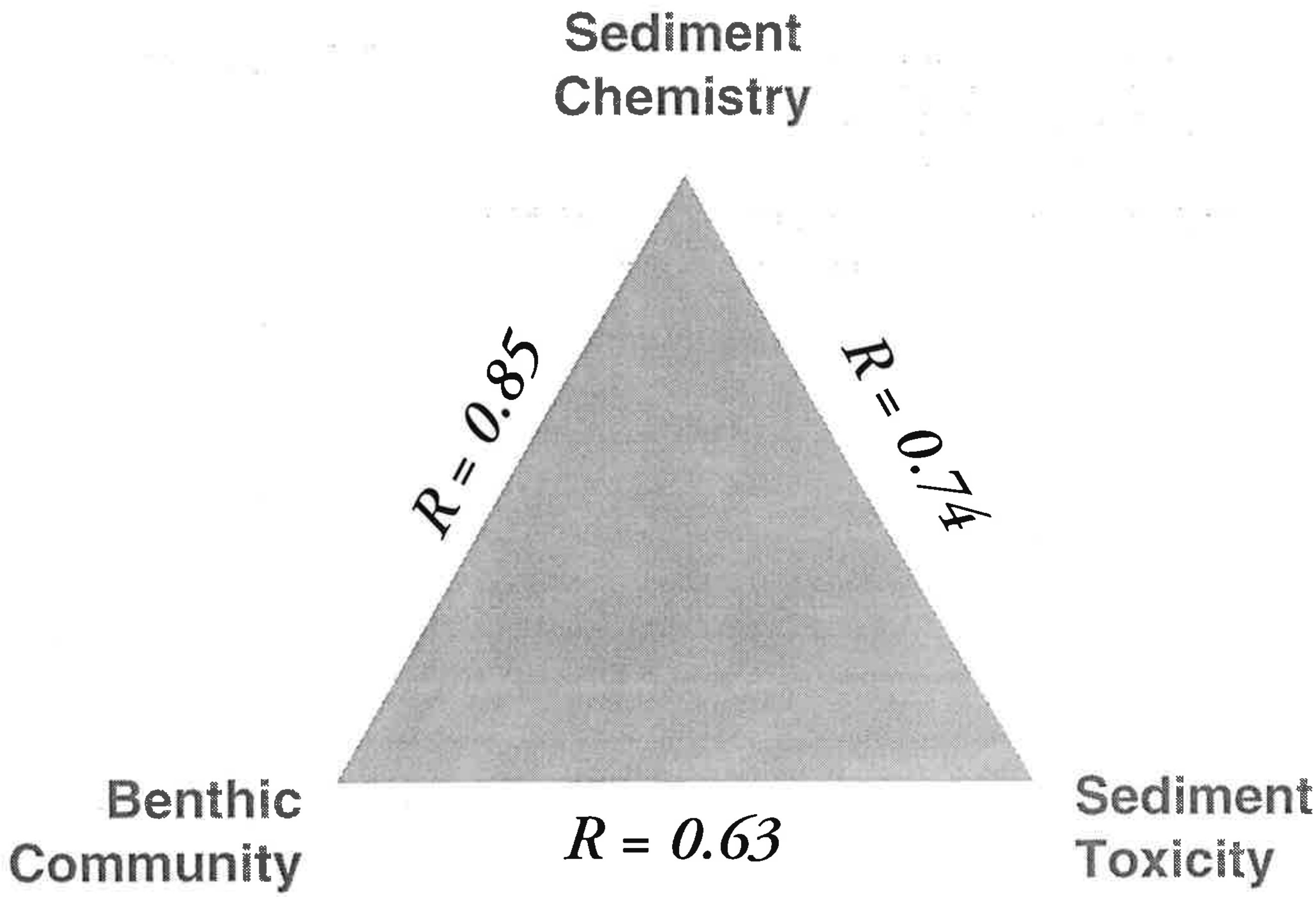
The "triad" hypothesis addresses the issue of whether chemical contaminants may be responsible for biological "effects" that are apparent in the study area. This hypothesis has not been articulated explicitly in the set of 13 hypotheses that were developed by the AETE (Section 1.0); however, it is consistent with the interest in H9 through H13 about the ability or relative ability of monitoring tools to detect correlations or relationships between chemical, toxicological and biological parameters. The basic approach to evaluation of the triad hypothesis was to simultaneously examine three types of correlations: chemical-toxicological (C-T), toxicological-biological (T-B) and chemical-biological (C-B). These are the three "arms" of the triad that would support an interpretation that chemical contaminants are responsible for biological effects. There should be significant correlations on all three arms before the hypothesis that chemical contaminants are the cause of the effect is accepted. Note that none of the 13 hypotheses is specific to the testing of C-T correlations.

Statistical approaches to triad evaluation follow Green and Montagna (1996) and Chapman (1996). One approach is to examine the three bivariate correlations (C-T, T-B, C-B) for different sets of chemistry, toxicity and biology monitoring tools. Then, the overall evaluation of the triad hypothesis is based on "weight-of-evidence" considerations (i.e., are there sets of parameters showing significant C-T, T-B **and** C-B correlations, how many sets are there that meet this criterion, and how strong are the correlations in general?). This approach is simple, but rather tedious when there are many different chemistry, toxicity and biology monitoring tools to be paired in different ways.

A more holistic approach was applied using principal components analysis (PCA) to reduce the large number of variables to one or two dominant principal components (PCs) representing the mine effect gradient in chemistry (based on the original chemical variables), one or two representing the gradient in toxicity, and one or two representing the gradient in biology. Then multiple correlation coefficients (R) are computed using the PC variables to represent the dominant C-T, T-B and C-B correlations (if any) on each arm of the triad. Mantel's test was used to produce a single measure of concordance on each arm of the triad, equivalent to R^2 (e.g., Figure 5.5). Finally, Bartlett's test of sphericity is applied to determine if there was a significant overall concordance across the three arms of the triad.

5.2 Results

The general conclusions with respect to the hypotheses tested at Myra Falls are summarized in Table 5.2. The following sections present the findings in more detail based on the statistical tables and figures provided in Appendix 4.



Approach to Evaluation of the Sediment Quality Triad

beak international incorporated | Figure 5.5 | April 1998

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS REGARDING HYPOTHESES TESTED AT MYRA FALLS

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis	Conclusion
H1	Sediment Toxicity Response i (Tool 1) Sediment Toxicity Response j (Tool 2)	Lake Number (in order of increasing distance from mine near-field, far-field, reference)	no lake x tool interaction by ANOVA	Mortality increased with exposure for *Hyalella* and *Chironomus* tests, but not for *Tubifex*. *Tubifex* responded in terms of reproductive effects.
H6	Indicator Taxa Benthic Density No. of Taxa EPT Index[1]	Lake Number or Creek (in order of increasing distance from mine)	no among lake or creek difference by ANOVA	Key indicator taxa abundances responded to exposure, including EPT index, Ephemerellidae, *Cricotopus* + *Orthocladius* and total Chironomid abundances in creek, *Pisidium* and harpacticoid abundances in Buttle Lake.
H9 *	Indicator Taxa Benthic Density No. of Taxa EPT Index	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2) (Myra Creek only)	same Y-X correlation with Tool 1 as Tool 2	Only one exposure level; therefore, correlations not possible. Dissolved and total metals higher in exposure area where effects on benthos were observed. Dissolved metals were a high percentage of total metal; therefore, correlations with benthic effects would be similar.
H10	Benthic Density No. of Taxa Sediment Toxicity Responses	Partial Metal i in Sediment (Tool 1) Total Metal i in Sediment (Tool 2) SEM/AVS ratio (Tool 1)[2]	same Y-X correlation with Tool 1 as Tool 2	Benthic indicators and sediment toxicity were correlated with both total and partial metals for As, Cd, Cu, Zn. Correlation coefficients for total and partial metals were similar for benthic indicators. Total metals were better correlated with toxicity than partial metals overall. The SEM/AVS ratio did not correlate with either benthic indicators or with sediment toxicity.

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS REGARDING HYPOTHESES TESTED AT MYRA FALLS

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis	Conclusion
H11	Benthic Density No. of Taxa Indicator Taxa	Sediment Toxicity Response i (Tool 1) Sediment Toxicity Response j (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	Benthic indicators (harpacticoids and *Pisidium*) were correlated with toxicity test results for *Tubifex* reproduction (positive correlation) and for *Hyalella* mortality (negative correlation). Chironomid mortality was not correlated with benthic indicators.
H13 *	Benthic Density No. of Taxa EPT Index Indicator Taxa	Predicted % Response in Exposure Reach	no Y-X correlation	Benthic effects were observed in the exposure area of Myra Creek, and occurred at aqueous metal concentrations producing chronic toxicity in *Ceriodaphnia, Lemna* and *Selenastrum*. Therefore, these tests appeared to effectively predict benthic effects. No fathead minnow response occurred in any test (lethal or sublethal)
Other Triad Hypotheses	Benthic PCs[3] Sediment Toxicity PCs Sediment Chemistry PCs	Benthic Variables (B) Toxicity Variables (T) Chemistry Variables (C)	no correlation C-B, C-T and B-T	The triad analysis showed significant correlations between sediment chemistry PCs and both benthic PCs and toxicity responses. The toxicity-benthic linkage was weaker, probably reflecting differences in the causative agents (sediment quality) for toxicity and benthic responses. Overall, the triad was significant and shows that sediment toxicity and benthic community tools respond effectively to mine-related contaminants.

[1] EPT = Ephemeroptera, Plecoptera, Trichoptera.
[2] SEM = Simultaneously Extracted Metal.
AVS = Acid-volatile Sulphide.
[3] PCs = Principal Components
* H9 and H13 examined qualitatively

5.2.1 H1 - Sediment Toxicity as a Response to Exposure

Figures illustrating the sediment toxicity response patterns, and ANOVA tables showing tests for significant differences in response patterns between toxicity test species, are provided in Appendix 4. Based on these patterns and statistical test results, the key findings regarding hypothesis H1 are outlined below.

Hyalella and *Chironomus* mortality (arcsine square root of %) both showed a trend of lower mortality (i.e., higher survival) with increased distance from the mine, and the far-field values were similar to the Brewster Lake reference values. Both test species showed significant among area variation, but there was no significant difference in the response patterns of these test species (i.e., no significant reach by tool interaction), indicating that both tools were equally effective in demonstrating a mine effect.

Tubifex mortality showed no response to mine exposure ($p = 0.875$), and this pattern was notably different than the *Hyalella* and *Chironomus* response patterns which did show significant mine-related trends.

Tubifex production of cocoons showed a significant among area variation and tends to increase with distance downstream. Cocoon production was greater in the Brewster Lake reference area than in far-field Buttle Lake. *Tubifex* production of young was similar in the near-field and far-field areas of Buttle Lake, and lower in Buttle Lake than in the Brewster Lake reference. Again, this pattern represented a significant among area variation ($p=0.011$). These two endpoints (cocoon versus young production) showed significantly different response patterns. A mine-related trend was better demonstrated with the number of cocoons per adult. *Tubifex* hatching success showed no responses to mine exposure.

Hyalella, Chironomus and *Tubifex* were all useful toxicity testing tools at demonstrating an effect at the Myra Falls site, however, *Hyalella* and *Chironomus* showed the highest level of toxicity in the near-field (i.e., most sensitive) when compared to the reference area toxicity values.

Hyalella and *Chironomus* growth endpoints were not tested because of the high mortality of organisms (in many cases 100%) at many of the stations.

5.2.2 H6 - Benthic Community Measures as a Response to Exposure

Figures illustrating benthic community response patterns in relation to mine exposure, and ANOVA tables showing tests of significance for these trends are provided in Appendix 4. Based on these patterns and statistical test results, the key findings regarding hypothesis H6 are outlined below, for Myra Creek and the two lakes.

Myra Creek

Benthic organism density (log no. of individuals/0.1m^2) and numbers of benthic taxa showed no significant differences between exposure and reference areas, although the reference area means were slightly higher.

Numbers of EPT taxa at the genus level and % Ephemerellidae were significantly different between areas ($p = 0.0004$ and 0.00001, respectively). These two indices were higher in the reference area compared to the exposure area. Ephemerellidae are included among the EPT taxa (mayflies, stoneflies and caddisflies). These taxa are generally considered to be more sensitive to pollution and are considered to be indicators of good water and sediment quality in lotic systems. In Myra Creek, the EPT index at the generic level demonstrated an effect even though no differences were found in total density and number of taxa. This is not an unusual effect because, in impacted environments, sensitive taxa are replaced by tolerant taxa.

The percentage of pollution-tolerant taxa, such as *Cricotopus* and *Orthocladius* were significantly different between areas and were more dominant in the exposure area than the reference area ($p < 0.0001$). These chironomid genera were useful in detecting mine effects on the benthic community. The percent chironomids was also significantly higher ($p = 0.005$) in the exposure area indicating a shift in community structure to one dominated by more metal tolerant taxa.

Brewster and Buttle Lakes

Benthic organism density was slightly higher in the reference area (Brewster Lake) compared to the invertebrate density in Buttle Lake exposure areas. The near-field area of Buttle Lake was quite variable but similar in average density to the far-field area. Overall, this variation among areas was not statistically significant but was close to being significant (p=0.058). Numbers of benthic taxa and % chironomid taxa showed no lake area differences.

Harpacticoid copepod density (log no. of individuals/0.1m^2) was significantly higher in the Brewster Lake reference area than in the Buttle Lake exposure areas (only one found at one station). This group appears to be a useful indicator of mine effects at this site, however, it may be reflecting natural variation between the two lakes. A mine-related trend in harpacticoid density was also observed in Myra Creek, suggesting that this group is sensitive to mine contaminants.

The density of fingernail clams (*Pisidium*) shows a similar pattern, with significant differences among lake areas. These clams are sensitive to metal pollution and are considered to be indicators of good water and sediment quality in benthic systems, as appears to be the case at this site. Despite the fact that sediment texture varied between Brewster and Buttle Lakes, *Pisidium* would still be expected to occur in the sediment type (sand and silt) found in Buttle Lake. Although *Pisidium* abundance appeared to suggest a mine-related trend, it is important to realize that this trend could be related to natural population variability between the two lakes.

5.2.3 H9 through H12

5.2.3.1 H9 - Dissolved vs Total Metal in Water as a Predictor of Biological Response

Because there was only a single level of exposure in Myra Creek, there were not sufficient data to perform correlation analyses. Significant effects were observed on the benthic invertebrate community in the exposure area of Myra Creek and water sample analyses clearly indicated that there were substantial increases in contaminants in this area. The dissolved metal fraction generally represented a high percentage of the total metal and in the case of zinc, which is a key contaminant at the Myra site, almost all of the metal was in the dissolved form. Therefore, there would not be much difference in the strength of the correlations with dissolved or total metal and the effects observed on the benthic community.

5.2.3.2 H10 - Partial vs Total Metal in Sediment as a Predictor of Biological (and Toxicity) Responses

Tables showing the correlation coefficients between sediment chemistry and biological measurements are provided in Appendix 4. Based on the magnitudes of the significant correlation coefficients, key findings regarding hypothesis H10 are outlined below for the Buttle Lake communities.

The total and partial metal concentrations in sediments from Buttle and Brewster Lakes were statistically tested to determine which metals showed a significant ($p<0.05$) mine-related trend (i.e., near-field concentration > far-field > reference).

For total metals, antimony, arsenic, barium, beryllium, cadmium, copper, molybdenum, silver, strontium and zinc showed significant trends. For partial metals, only barium, cadmium, copper and zinc showed significant trends. The key contaminants at Myra would be arsenic, cadmium, copper and zinc. Relationships between these metals and effects on the benthic community and sediment toxicity results were evaluated to address Hypothesis H10.

Correlations between sediment metals (total and partial) and number of taxa, density and percent chironomids were not significant. This is not surprising given that there were no significant differences in these benthic measures among areas, although the trend in invertebrate density was close to being significant ($p = 0.058$, Hypothesis H6). Sediment metal correlations with the indicator taxa Harpacticoida and *Pisidium* were significant (i.e., negative correlations consistent with a mine effect). Total sediment metal (arsenic, copper, cadmium and zinc) correlations with these benthic community measures were similar to the partial metal correlations. Overall, there is little reason, based on effectiveness, to choose one of these metal-in-sediment chemistry tools over the other. Caution must be exercised when interpreting these correlations because the differences between lakes for these two indicator taxa may be related to natural variation.

The SEM/AVS ratio was not significantly correlated with any of the benthic community measures. However, as discussed in Section 4.0, the ratio was not developed to be used as a predictor of benthic community effects, but as a predictor of acute sediment toxicity.

Total sediment metal correlations with acute sediment toxicity measures (i.e., *Hyalella, Chironomus*) were higher than the corresponding partial metal correlations for all of the metals tested (i.e., arsenic, cadmium, copper, zinc); however, the partial metal correlations were slightly higher for *Tubifex* reproduction. The correlations of metals versus acute toxicity, which were based on 21 data points, were quite strong (correlation coefficients 0.68 to 0.92). Those with *Tubifex* reproduction (number of young per adult) were weaker (i.e., correlation coefficients < -0.6), whereas the correlations with number of cocoons per adult were similar to those with *Hyalella* and *Chironomus*.

Overall, it appears that the total sediment metal chemistry tool was slightly more effective as a predictor of acute toxicity.

The SEM/AVS ratio does not appear to be useful as a predictor of acute sediment toxicity at this site, based on low correlation coefficients ($r \leq 0.30$) that were not statistically significant. Figure 5.6 shows the relationship between the SEM/AVS ratio and acute toxicity. Ratios <1 represented sediments that were not toxic; however, ratios >1 reflected sediments that were toxic and some that were not toxic. The ratio predicted the acute toxicity observed in the near-field; however, based on the ratios for the far-field stations, a similar level of toxicity would be expected. This was not the case, because toxicity in the far-field was similar to that observed at the reference sites where the ratios were generally <1.

5.2.3.3 H11 - Sediment Toxicity as a Predictor of Biological Response

Tables showing the correlation coefficients between sediment toxicity and biological response are provided in Appendix 4. Based on the magnitudes of the significant correlation coefficients, the key findings regarding hypothesis H11 are outlined below for the Myra Lake communities.

Hyalella mortality and *Tubifex* reproduction were significantly correlated with harpacticoid copepod density and with *Pisidium* (fingernail clam) density ($p < 0.05$). These two sediment toxicity tests were correlated in opposite directions, as expected from the nature of the toxicity endpoints (high mortality coincides with low reproduction). Chironomid mortality was negatively correlated with harpacticoids and *Pisidium,* but the correlations were not statistically significant. Correlations with invertebrate density, number of taxa and percent chironomids were not significant ($p > 0.05$).

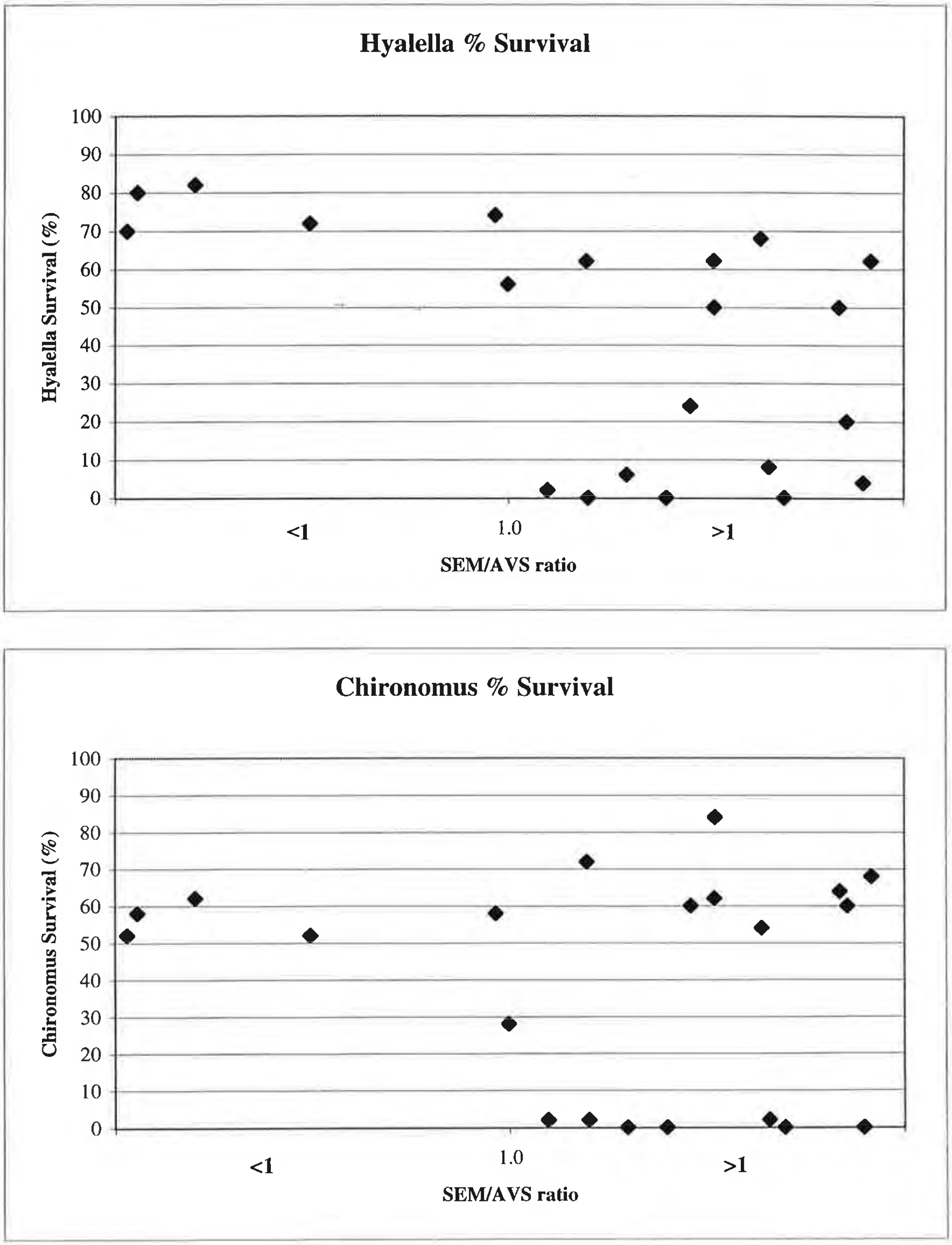


Figure 5.6: Sediment Toxicity versus Ratio of Simulatneously Extracted Metals (Cd+Cu+Ni+Pb+Zn)/Acid Volatile Sulphide. Myra Falls, September 1997.

5.2.4 H13 - Chronic Toxicity Linkages with Benthic Monitoring Results

Because there were only two areas in Myra Creek (reference and one exposure area), this hypothesis could not be tested. However, as discussed previously, effluent concentrations in the exposure area were estimated to be 15% during the time of field survey, based on sulphate measurements. Moreover, the loadings of zinc are augmented substantially by inputs from other sources. Chronic effects from zinc in Myra Creek are plausible since zinc levels in the 30 September final effluent were around 0.14 mg/L (Table 4.1) and concentrations in the exposure area, two weeks prior, were around 0.35 mg/L (Table 4.3) approximately twice the effluent concentration.

The lowest IC25 values for *Ceriodaphnia*, *Selenastrum*, and *Lemna* were 16, 18, and 19% effluent, respectively. The estimated effluent concentration in Myra Creek based on sulphate (15%) approaches these effect levels, and based on zinc there could be an equivalent of 250% effluent in the creek (i.e., zinc in the creek was 2.5 times greater than in effluent). Therefore, the results of the chronic toxicity tests, with the exception of fathead minnow, predicted that an effect on biological communities would be expected in the exposure area. Results of testing of Hypothesis H6 indicates that there were significant changes in the benthic community in the exposure area compared to the communities in the reference area (Section 5.2.2).

The data suggest that *Ceriodaphnia, Selenastrum* and *Lemna* chronic toxicity tests are effective tools in predicting potential effects in the receiving environment. However, as seen for Myra Falls Operations, mine sites may have other sources of contaminants which are not accounted for by testing of the main mine effluents. The fathead minnow test was not an effective test for predicting mine effects on invertebrates.

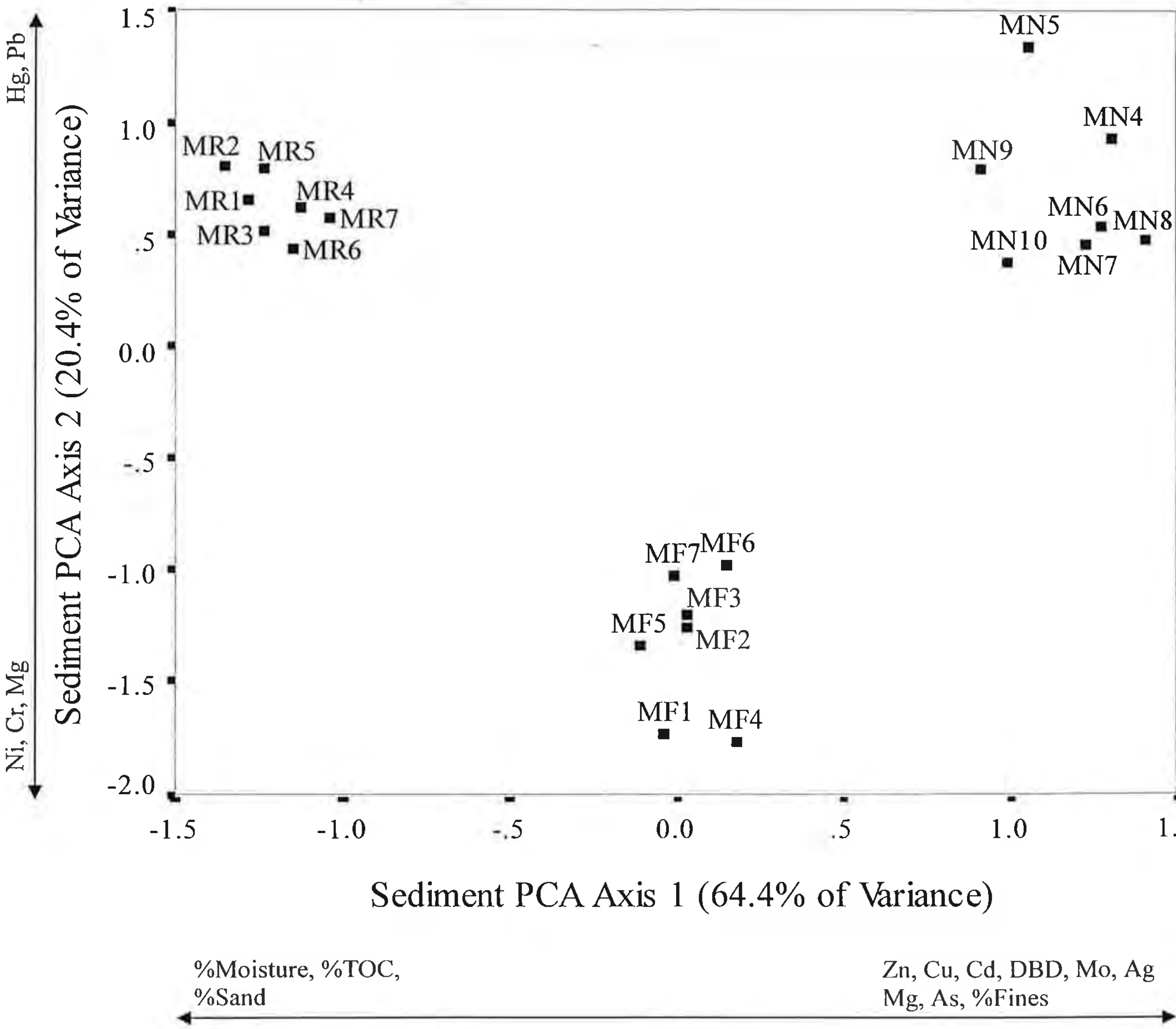
5.2.5 Triad Hypotheses

There are a number of combinations of chemistry (C), toxicity (T) and biology (B) monitoring tools that show significant correlations on all three arms of the "triad". The correlations involving total metals are slightly higher, in general, than those involving partial metals, although there is little practical difference between these tools. The correlations involving *Hyalella* and *Chironomus* mortality and *Tubifex* reproduction were generally higher than those involving other toxicity measures. The C-B correlations involving Harpacticoida and *Pisidium* with sediment chemistry were generally higher than those involving other benthic community measures with sediment chemistry.

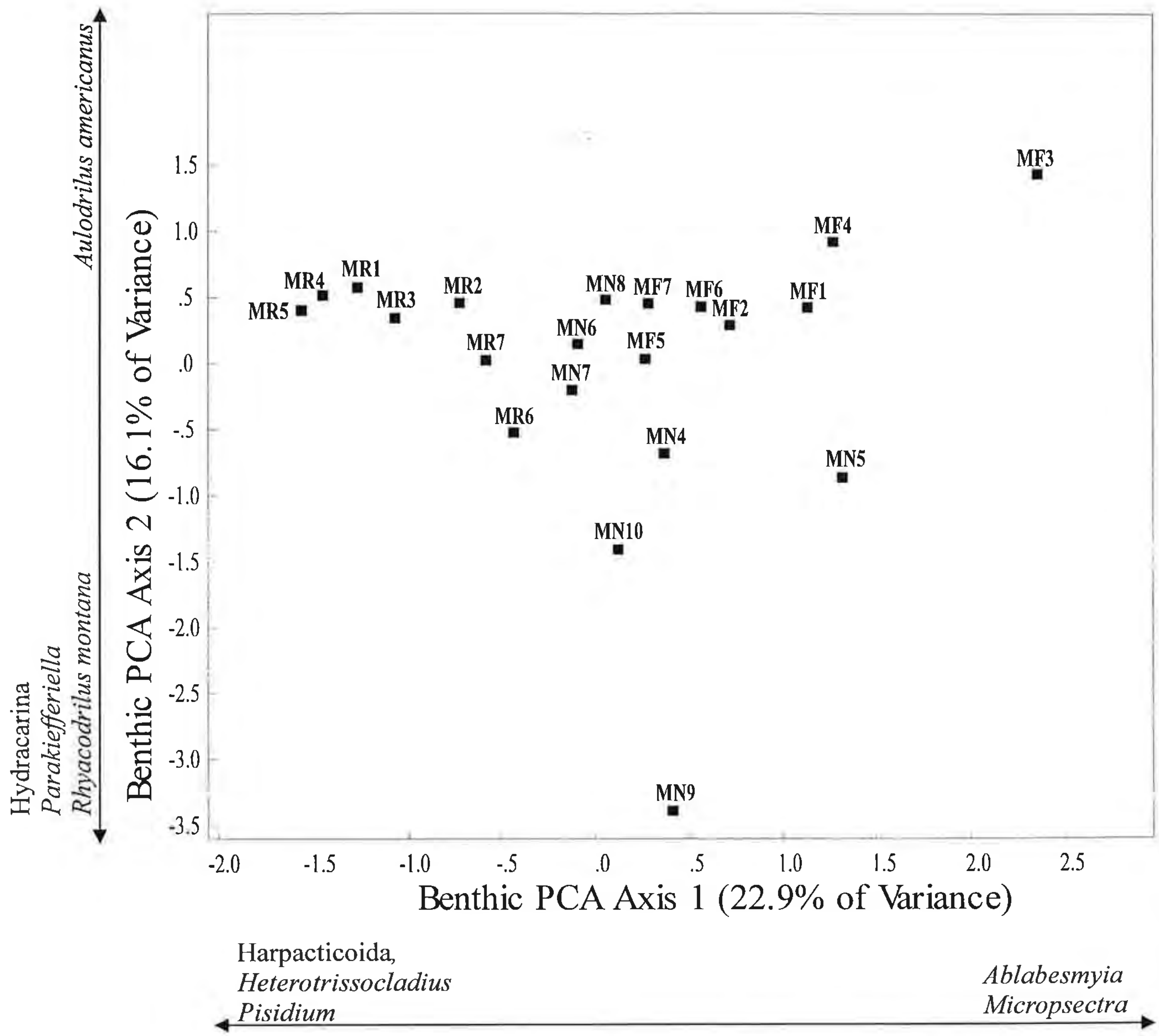
A more holistic evaluation of the sediment quality triad, involving multivariate analysis, is presented in Appendix 4. The many sediment chemistry variables were reduced by principal components analysis (PCA) to two sediment principal components (SPCs) representing sediment chemistry gradients. This PCA used total metals but not partial metals or SEM/AVS results because total metals were most effective in hypothesis testing. The dominant SPC1, accounting for most (64%) of the overall variation in sediment chemistry, primarily represents a sediment texture gradient from fine material (with associated metals, in particular copper, cadmium, molybdenum and zinc) to coarse material (with associated organic matter and moisture). These parameters separated the reference stations from the near-field and far-field stations (Figure 5.7). The subdominant SPC2, accounting for 20% of the variation in sediment chemistry, represents variation in metal composition, with more nickel, chromium and magnesium at one end representing far-field stations, versus mercury, lead and silver at the other, representing the near-field and reference stations. SPC1 represents the mine effect on sediment quality.

The many benthic community variables were reduced by PCA to two benthic principal components (BPCs) representing gradients in the biological make-up of the community. The dominant BPC1, accounting for 23% of the overall variation in species composition, primarily represents harpacticoids, the chironomid *Heterotrissocladius,* the fingernail clam (*Pisidium*) (pollution sensitive taxa) at one end of the axis and the chironomids *Ablabesmyia* and *Micropsectra* (pollution tolerant taxa) at the other end (Figure 5.8) . This axis separated reference from near-field and far-field stations. The subdominant BPC2, accounting for 16% of the variation in taxa composition, represents water mites (Hydracarina), the oligochaete *Rhyacodrilus* and the chironomid *Parakiefferiella* at one end (associated with some of the more toxic near-field stations) and the tubificids *Aulodrilus americanus* at the other end. Both benthic gradients may be mine-related.

The dominant sediment chemistry gradient (SPC1) was significantly correlated with the five main taxa from BPC1 (multiple $R = 0.82$, $p < 0.001$; Figure 5.9). This gradient (SPC1) was also significantly correlated with sediment toxicity as reflected by *Chironomus* and *Hyalella* mortality and *Tubifex* production of young (multiple $R = 0.92$, $p < 0.001$), indicating that the more contaminated sediments were more toxic. Thus, the linkages of

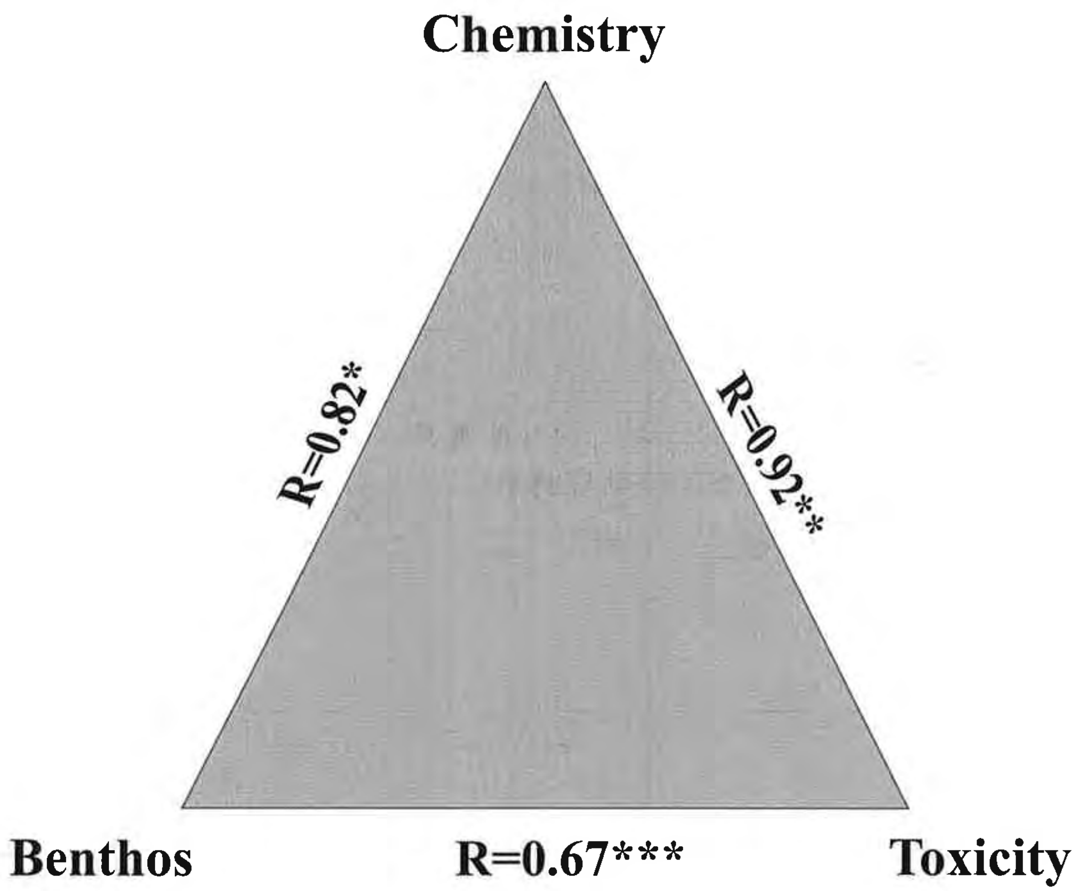


Sediment PCA Results Myra Falls Lake Stations		
beak international incorporated	Figure 5.7	May 1998



Benthic PCA Results
Myra Falls Lake Stations

beak international incorporated	Figure 5.8	May 1998



Bartlett Sphericity Test = 93.9 ($p<0.001$)

*** the relationship between sediment chemistry PCA Axis 1 and the abundance of Harpacticoida, *Heterotrissocladius, Pisidium, Ablabesmyia* and *Micropsectra* in the benthic community is statistically significant. Sediment PCA 1 represents a gradient in metals (zinc, copper, cadmium and molybdenum), dry bulk density, %moisture, %TOC and %sand.**

**** the relationship between sediment chemistry PCA Axis 1 and the toxicity tests (*Chironomus, Hyalella* and *Tubifex*) is statistically significant. Sediment PCA 1 represents a gradient in metals (zinc, copper, cadmium and molybdenum), dry bulk density, %moisture, %TOC and %sand. *Chironomus* and *Hyalella* results represent acute toxicity while *Tubifex* results represent chronic toxicity (number of young/adult).**

***** the relationship between benthic PCA Axis 2 and the toxicity tests (*Chironomus, Hyalella* and *Tubifex*) is statistically significant. Benthic PCA Axis 2 represents the presence of a number of tolerant organisms present primarily at the nearfield stations associated with toxicity. *Chironomus* and *Hyalella* results represent acute toxicity while *Tubifex* results represent chronic toxicity (number of young/adult).**

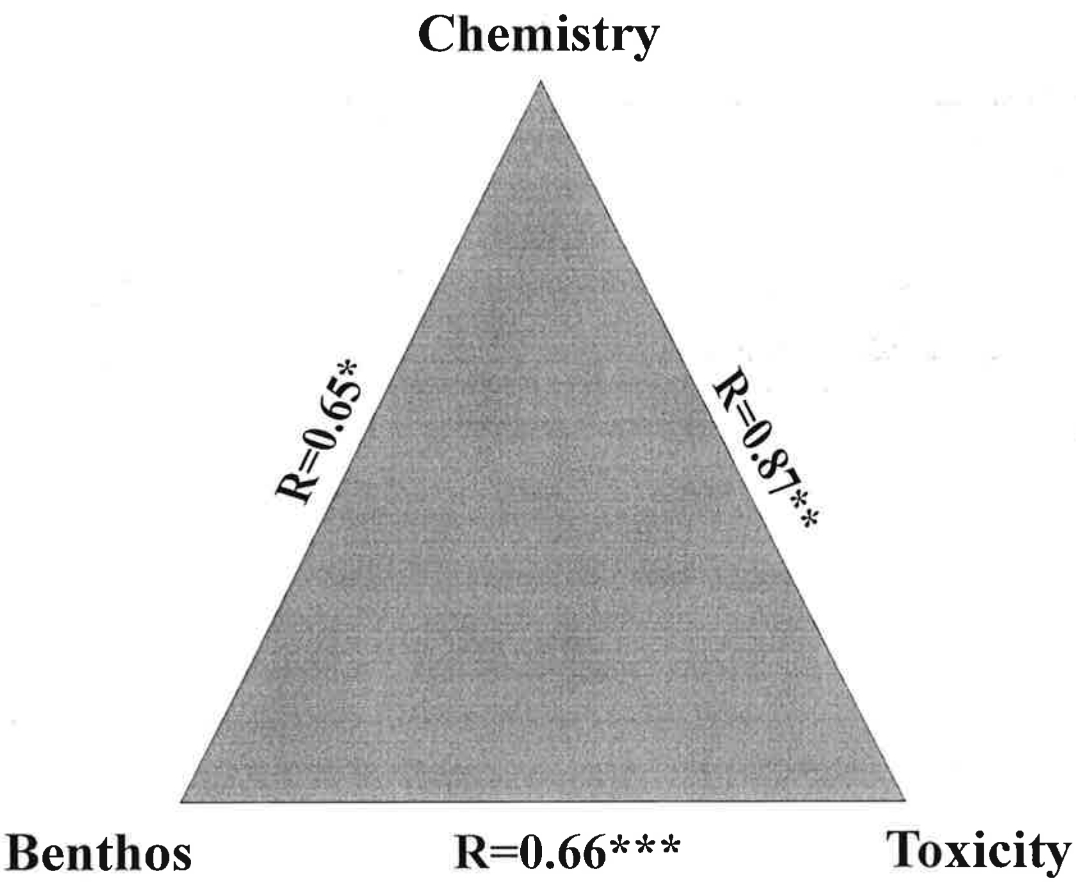
Triad Approach to Evaluate Sediment Quality		
beak international incorporated	Figure 5.9	May 1998

sediment chemistry with the benthic community response and with toxicity were both strong, providing a weight of evidence that contaminants are causing the responses.

The dominant benthic community gradient, BPC1 (harpacticoids and fingernail clams), was not significantly correlated with sediment toxicity, although toxicity was correlated significantly with the key taxa of BPC2 (as listed above). This is because hydracarina, *Parakiefferiella* and *Rhyacodrilus* occurred mainly in sediments where higher toxicity was measured, whereas harpacticoids and *Pisidium* were absent at most exposure stations.

Based on Bartlett's sphericity test, and using only the mine-related sediment quality and benthic community gradients, the sediment quality triad overall is significant, demonstrating that chemistry, benthic and toxicity tools are effectively linked.

Use of the Mantel's test comparing the euclidean distance matrices supported these results. The Mantel's test indicated that all three arms of the sediment quality triad were significant (Figure 5.10) which suggests that the sediment chemistry and biological response tools are effectively linked, and the contaminants measured may be the cause of the response.



Bartlett Sphericity Test = 37.36 (p<0.001)

*** the relationship between sediment chemistry and the benthic community is statistically significant.**

**** the relationship between sediment chemistry and the toxicity tests (*Chironomus, Hyalella* and *Tubifex*) is statistically significant.**

***** the relationship between the benthic community and the toxicity tests (*Chironomus, Hyalella* and *Tubifex*) is statistically significant.**

Note: the 'R' as used here is equal to the $\sqrt{Z_M}$ presented in the table of Mantel results (Appendix 4), each Z_M is based on concordance of two euclidean distance matrices.

Triad Approach Using Mantel's Test to Evaluate Sediment Quality		
beak international incorporated	Figure 5.10	May 1998

6.0 EVALUATION OF AQUATIC EFFECTS TECHNOLOGIES

6.1 Introduction

The Myra Falls Operations Field Evaluation program evaluated several of the aquatic effects monitoring "tools" considered by the AETE program. These tools were evaluated through testing six of the thirteen hypotheses (two qualitatively) pertinent to the 1997 field program, as well as by examination of other tool performance indicators other than those specific to these hypotheses (e.g., sediment quality triad, chironomid deformities, practical aspects). To avoid repetition, the cost-effectiveness aspects of the monitoring technologies are considered collectively in a summary report on all four of the 1997 field sites, because costs for each specific technology were approximately equal at the four sites (BEAK and GOLDER, 1998b). The summary report also evaluates the overall effectiveness of each monitoring tool, based on the results of all four sites.

Monitoring tools may be organized within "tool boxes" under the four guiding questions formulated under the AETE program to develop the hypotheses tested (from Section 1.1):

1. Are contaminants getting into the system?
2. Are contaminants bioavailable?
3. Is there a measurable (biological) response? and
4. Are contaminants causing the response?

Tool boxes and monitoring tools may be categorized under these four questions. Some tools may logically fit under more than one question; for example, toxicity testing tools may fit under Questions 1, 2 or 3. Table 6.1 provides a reasonable framework for organization of these tools, although alternate frameworks may be equally valid.

The fourth question cannot be answered by the application of individual tools, unlike the first three questions. Rather, the fourth question can be answered only by integrating the use of tools between and among tool boxes through testing for statistical linkages between potential cause and effect variables (e.g., do chemical concentrations and biological measurements correlate with one another? -evaluated following the Sediment Quality Triad approach). The most effective tools are clearly those used in combinations that provide a yes answer to Question No. 4.

TABLE 6.1: GUIDING QUESTIONS, TOOL BOXES AND TOOLS CONSIDERED IN THE 1997 FIELD PROGRAM. TOOL BOXES AND TOOLS IN BOLD PRINT ARE SPECIFICALLY CONSIDERED AT MYRA FALLS

Question	Tool Boxes	Tools
Are contaminants getting into the system?	**Water chemistry**	• **total metal concentrations** • **dissolved metal concentrations**
	Sediment chemistry	• **total metal concentrations** • **partial metal concentrations** • **acid volatile sulphide and sequentially extracted metals**
Are contaminants bioavailable?	Fish tissues	• organ/tissue metal concentration • organ/tissue metallothionein concentration
Is there a measurable response?	**Effluent chronic toxicity**[1]	• **fathead minnow survival and growth test** • ***Ceriodaphnia dubia* (microcrustacean) survival and reproduction test** • ***Selenastrum capricornutum* (algae) growth test** • ***Lemna minor* (duckweed) growth test**
	Sediment toxicity	• ***Chironomus riparius* (larval insect) survival and growth test** • ***Hyalella azteca* (crustacean) survival and growth test** • ***Tubifex tubifex* (aquatic worm) survival and reproduction test**
	Fish health indicators	• fish growth (length, weight and age) • fish organ size
	Fish population/community health indicators	• fish catch-per-unit-effort (CPUE - by species and total) • fish biomass-per-unit-effort (BPUE - by species and total)
	Benthic community health indicators	• **densities of benthic invertebrates** • **numbers of benthic invertebrates** • **benthic community indices (e.g., EPT index)** • **frequency of chironomid deformity**
	Periphyton community health indicators	• periphyton community biomass • numbers of periphyton taxa
Are contaminants causing the response?	**Pair-wise combinations of the above tool boxes**	• **chemistry x biology tool correlations** • **toxicity x biology tool correlations** • **chemistry x toxicity tool correlations** • **Sediment Quality Triad**

[1] Effluent chronic toxicity measured in the laboratory may also be categorized under Questions 1 or 2 (Are contaminants getting into the system?, or, Are contaminants bioavailable?).

The hypotheses are formulated to answer two general types of questions:

- Is the tool effective in measuring a mine effect (i.e., is there a reference - exposure difference or an exposure area gradient)?; and
- Is one tool more effective than another in measuring an effect?

The "effectiveness" of monitoring tools as discussed herein is specific to the Myra Falls data set. Myra Falls represents one of four mine sites considered in the AETE 1997 Field Evaluation Program, and only one of numerous mine sites across Canada. A tool that is found to be of little value at Myra Falls for detecting mine effects may be very useful at other sites and vice versa. Therefore, the reader is cautioned not to assume that the conclusions drawn with Myra Falls data will necessarily be broadly valid at mines across Canada. As shown in the AETE 1997 Field Program Summary Report (BEAK and GOLDER, 1998b), monitoring tools can respond very differently from site to site. Also, the presence or absence of a particular mine-related effect may simply reflect exposure level or metal bioavailability at the site. In the latter case, the absence of an effect may simply indicate that the tool was suitable for showing no effect. However, the degree of impact found at Myra Falls and the aqueous and sediment concentrations of metals present are consistent with conditions which should demonstrate the effectiveness of monitoring tools unless they are insensitive.

6.2 Are Contaminants Getting Into the System?

6.2.1 Water Chemistry Tool Box

Hypothesis Testing Aspects

At Myra Falls Operations, water chemistry sampling in Myra Creek showed that metals were "getting into the system". This was demonstrated by a downstream increase in total and dissolved concentrations of most metals (e.g., zinc, copper, lead, cadmium, magnesium, manganese, nickel, potassium and aluminum). In the near-field area of Buttle Lake, water concentrations of cadmium, manganese, and zinc clearly demonstrated that metals were getting into the system.

In a qualitative evaluation of Hypotheses H9, measured aqueous concentrations of metals from Myra Creek were effective in predicting benthic community effects (density, numbers of taxa, EPT index at the generic level, % Ephemerillidae, % *Cricotopus/Orthocladius* and % Chironomidae).

Benthic community responses would be similarly predicted by dissolved metal and total metal concentrations in Hypothesis H9 because a large percentage of aqueous metal was in the dissolved form.

Other Considerations

The collection of dissolved metal samples according to the methods described in Annex 1 was not onerous, but required approximately five technician hours (additional relative to total metal samples) to filter and preserve the 19 samples (17 plus 2 field duplicates) and appropriate filter blanks.

The syringes required, based on recommendations by chemists at the Geological Survey of Canada (GSC), were difficult to procure in Canada. Importation of the syringes from the U.S. required over one month due to delays at Canada Customs. Availability of similar filtration materials necessary for ultra-trace metal work may be problematic, requiring careful planning.

The commercial laboratory used required very specific instruction to provide sampling containers and filtration materials consistent with the specifications provided by GSC. For example, commercial laboratories often provide low density rather than high density polyethylene containers for metal samples, and may also provide containers with coloured lids such as "Falcon" tubes to consultants or mining companies. GSC has shown that such containers can contribute low levels of metals to water samples, and thus may not be suitable in aquatic effects monitoring where metal concentrations of interest are equal to or often below surface water quality guidelines.

The filtration procedure involved squeezing the water through a syringe-mounted filter, and was somewhat difficult and time-consuming due to the slow rate of filtration, rinsing requirements, etc. Also, where suspended solids levels are higher (generally not at Myra Falls), filters became quickly clogged and required replacement.

Sample contamination was apparent in the dissolved metal results where, on occasion, the dissolved metal concentrations were higher than the total metal concentrations. Comparison of the filter blanks to the field and travel blanks showed that the filtering process added aluminum, chromium, copper, iron, lead, and zinc to the samples. The data indicate that a greater potential for sample contamination exists for dissolved metals than for total metals owing to the handling required.

To conclude, water chemistry (metal concentration) measurements were effective predictors of biological effects on benthos at Myra Falls. Dissolved and total metal concentrations were considered to be equally effective predictors of aquatic effects. However, because of the added handling for the filtering process which increases the costs and the potential for contamination, total metals may be considered to be the better tool for monitoring water chemistry at Myra Falls.

6.2.2 Sediment Chemistry Tool Box

Hypothesis Testing Aspects

In Buttle Lake, sediment concentrations of most metals demonstrated that contaminants were getting into the system, although most of these metals originated from historical deposition of tailings into Buttle Lake and do not represent current discharges from the mine. The sediment chemistry tools of total metals, partial metals and SEM/AVS were evaluated through Hypothesis H10 by identifying reference versus exposure differences or concentration trends within the exposure gradient (near field to far field), and by examination of correlations of sediment metals with biological responses (both benthic and sediment toxicity), potentially reflecting cause-effect relationships.

In general, significant reference-exposure differences were observed for total metal concentrations of antimony, arsenic, barium, beryllium, zinc, silver, strontium, molybdenum, cadmium and copper. Partial metals only showed significant reference-exposure trends for barium, cadmium, copper and zinc.

Total metal and partial metal concentrations provided some value in predicting mine-related effects on benthic communities. However, total metals showed slightly higher correlations with sediment toxicity responses, suggesting that it may be a slightly more effective tool. The SEM/AVS results did not show any significant correlation with the benthic measures or sediment toxicity results, indicating that this sediment tool was not effective in predicting effects on the Buttle Lake benthic community. The SEM/AVS ratio was developed as a predictor of acute sediment toxicity. At Myra Falls, although SEM/AVS ratios <1 reflected sediments that were not acutely toxic, ratios >1 reflected both toxic and non-toxic sediments.

Other Considerations

The total metal sediment chemistry tool was considered to be only slightly more effective than the partial metal tool. The use of partial metals requires that the field crew have access to a freezer or dry ice since the samples have to be frozen immediately after collection. The samples must also be kept frozen during transport to the analytical laboratory. In some field situations, this could increase the cost of sample collection, further decreasing the cost-effectiveness of this tool.

Sediment metal analyses may be more effective than aqueous metal analyses in situations where aqueous metal concentrations are affected only sporadically (e.g., only in response to runoff or to intermittent effluent discharge), with concentrations approaching reference conditions between these impact events. This is because sediments will act to integrate metal loadings gradually over time whereas the water column may flush more rapidly.

The ineffectiveness of AVS and SEM determinations is perhaps not surprising, given the underlying assumptions in the SEM/AVS model. The SEM/AVS model relates the molar concentration ratio of potentially toxic sequentially extracted metals (Cd, Cu, Pb, Ni, Zn) to the molar concentration of amorphous solid metal sulphide (predominantly FeS; Allen *et al.*, 1993). Where the SEM/AVS ratio is >1.0, some of the metals are not made unavailable by the formation of metal sulphides and, therefore, toxicity may occur (e.g., Long *et al.*, 1998). In many mining-impacted sediments, including those in Buttle Lake, metals are often introduced to the environment in complex metal sulphide minerals in tailings or other solids, and are not controlled in their mobility by simple monosulphide forms. The large fraction of sulphide mineral present and the uncertain behaviour of minerals such as pyrite (iron sulphide), sphaleride (zinc sulphide), chalcopyrite (copper sulphide) and galena (lead sulphide) in the extraction potentially introduces a major uncertainty relating to the assumptions associated with the model.

6.3 Are Contaminants Bioavailable?

This question is answered through the measurement of metal bioaccumulation or biochemical responses to metal bioaccumulation. No tools falling under this question are tested at Myra Falls. The fact that there was effluent and sediment toxicity and that impacts were observed on the benthic community in Myra Creek suggest that metals are bioavailable.

6.4 Is There A Measurable Effect?

The answer to this question is evaluated through Hypotheses H1, H6, H9, H10, H11 and H13. All of the hypotheses tested at Myra Falls are based on a measurable effect and the integration of tool hypotheses (H9, H10, H11 and H13) look for correlations between the measurable effect and the potential causal agents. Hypothesis H11 actually examines correlations between two measurable effects (sediment toxicity and benthic invertebrate community response).

6.4.1 Effluent Chronic Toxicity

Hypothesis Testing Aspects

Results of effluent chronic toxicity tests were consistent with *in-situ* effects seen in the benthic community in Myra Creek, for three of the four effluent toxicity tests. The only exception was the fathead minnow tests which showed no lethal or sublethal response to the mine effluent. This consistency is intuitively reasonable, because chronic effects in laboratory tests occurred at effluent zinc concentrations lower than found in the exposure area. The chronic toxicity tools cannot be tested rigorously under hypothesis H13, because the effluent was not the principal source of metals present in the creek during the field program.

Other Considerations

Of the four tests, *Selenastrum, Ceriodaphnia* and *Lemna* were the most sensitive to Myra Falls Operations effluent, whereas the fathead minnow test was the least sensitive. As documented in the Summary Report (BEAK and GOLDER, 1998b), similar toxic responses were obtained in chronic testing of *Ceriodaphnia* using Myra Falls site dilution water versus laboratory dilution water having a hardness similar to site water. Thus, for Myra Falls, little or no change in toxicity was achieved in site dilution water.

Testing of H13 as worded could have been undertaken more directly by measuring chronic toxicity in water collected from the exposure area in Myra Creek. In this way, linkages between causal agents (toxicity) and biological response would be based on data from the site rather than from toxic responses predicted indirectly from testing of effluent. This would also have accounted for contaminants originating from other mine sources (e.g., seepages), which represented the most important source of metals to the creek during the survey.

In terms of the practical aspects of the testing, use of site dilution water added a level of difficulty to test logistics. In particular, use of site dilution water added to the acclimation requirements for fathead minnow and *Ceriodaphnia*, and necessitated additional sampling effort and shipping expense.

6.4.2 Sediment Toxicity

Hypothesis Testing Aspects

The effectiveness of sediment toxicity as an indicator of mine effects is measured from the identification of differences in toxicity between reference and exposure areas and/or the occurrence of trends within the exposure areas (near-field to far-field). Effectiveness is also determined by the strength of correlations between possible causal agents (metals in sediment) and sediment toxicity.

The toxicity of sediments in the exposure area was evident in all three test species. *Hyalella* and *Chironomus* showed similar patterns, while the *Tubifex* test showed different patterns depending on which endpoint measure was used (i.e., cocoon production, young production, cocoon hatching success). *Hyalella* and *Chironomus* tests were more sensitive (showing both lethal and sublethal responses) than the *Tubifex* test (showing relatively small sublethal responses) since they showed a greater degree of response between reference and exposure site sediments.

The toxicity results indicated that there was a mine-related effect, and this was most notable in the near-field area where *Hyalella* and *Chironomus* mortality was quite high (often 100%). There were also significant correlations with both total and partial metals and sediment toxicity. Correlations tended to be stronger with total metals than with partial metals. The results for the SEM/AVS versus toxicity results indicated the SEM/AVS ratio was not significantly correlated with the sediment toxicity data, and was ineffective in predicting sediment toxicity at this site.

Other Considerations

From a practical standpoint, although all toxicity tests responded to elevated sediment metals levels, *Hyalella* and *Chironomus* were the most sensitive tools since they showed the largest change in response from reference to near-field areas. *Tubifex* testing is not currently widely available from commercial laboratories and the cost per test for the *Tubifex* test is expected to be higher than the cost of *Hyalella* or *Chironomus* tests.

6.4.3 Benthic Community Health Indicators

Hypothesis Testing Aspects

Monitoring of benthic community parameters was effective in identifying responses to mining effects in the exposure areas at Myra Falls in both riverine and lacustrine habitats, with effects on EPT index occurring in stream habitat, and numbers of specific indicator taxa responding effectively both in stream and deep lake habitats. This effectiveness was evident in terms of reference-exposure differences and with respect to correlations with aqueous and sediment metal concentrations.

Benthic indices could be predicted based on metal concentrations in the water and on total metals in sediment. This strengthens the conclusion that the response is associated with metal exposure. No associations were seen between benthic indices and SEM/AVS results, suggesting that this was not an effective tool in predicting benthic effects.

Other Considerations

The collection of benthos for analysis at Myra Falls was accomplished readily and required routine effort. The collection of benthos from Myra Creek was straightforward and the collection of benthos from depths greater than 30 m in Buttle Lake was accomplished with the use of a power winch. Without the power winch, the effort to collect samples from this depth would have been substantial. Power winches suitable for benthic sampling are not available commercially "off-the-shelf", but need to be designed and constructed to specification according to the capacity of the sampling boat and portability constraints.

The incidence of chironomid deformity, based on examination of mouth parts in mounted specimens, was low throughout the reference and exposure areas (Appendix 5), indicating that this tool would be ineffective in measuring biological responses to metals at Myra Falls.

6.5 Are Contaminants Causing the Responses?

As indicated previously, this question is not answered directly through the application of specific monitoring tools evaluated in this study, or through any of the hypotheses tested. Rather, the question is evaluated only by a weight-of-evidence provided by affirmative responses to the first three questions, and particularly by the strength of correlations between exposure indicators (chemical concentrations) and biological responses in hypotheses H9 through H13.

At Myra Falls, evidence indicates that contaminants are getting into the system and are bioavailable (based on effluent and sediment toxicity data), and that certain biological responses are correlated with metal concentrations in the environment. Certain benthic community responses were correlated with sediment concentrations of metals in Buttle Lake, and the directions of exposure-response relationships are consistent with biological effects. Furthermore, *in situ* toxicity predicted from laboratory toxicity testing also reflected biological effects. Accordingly, the field data support a conclusion that "contaminants are causing the responses". However, dose-response relationships in the field do not necessarily prove cause and effect. Rather, a combination of controlled laboratory testing of metal toxicity and field evidence such as provided herein would be appropriate to provide further detail on cause and effect (e.g., which metals individually or in combination produce a response).

Sediment Quality Triad

The sediment quality triad also uses a weight of evidence approach to suggest if contaminants are causing the response. The analysis of the sediment quality triad showed that overall, linkages were strong between sediment chemistry and both benthic community response and sediment toxicity. The correlation between sediment toxicity and benthic community response was somewhat weaker than the other two arms of the triad, probably reflecting different causative agents for biological and toxicological responses or an acclimation effect for the benthos. Overall, the analysis shows that as a group, sediment toxicity and benthic community tools were responsive to sediment chemistry conditions that were influenced by mining.

6.6 Section Summary

Table 6.2 provides a summary of whether or not the aquatic monitoring tools evaluated at Myra Falls demonstrated a mine-related effect. Table 6.3 compares the effectiveness of alternate tools that may be used to measure metal concentrations, metal bioavailability or biological response.

Overall, most of the tools evaluated were effective at demonstrating a mine effect with the exception of the fathead minnow chronic toxicity tests and the SEM/AVS analysis. Fish were not collected at the Myra Falls site so the effectiveness of the fathead minnow test could not be fully evaluated. Of those tools that were effective, some were slightly more effective than others as predictors of biological response. Therefore, the costs of each tool will be important in the selection of which is considered to be the most cost-effective monitoring technology. These comparisons are provided in a separate document which summarizes the results of all four mine sites studied in 1997 (includes Heath Steele, Mattabi and Dome site results) and evaluates the cost-effectiveness of each monitoring tool.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT MYRA FALLS

Tool Boxes	Tools	Effectiveness		Comment
		Effect Demonstrated	Effect Not Demonstrated	
Water Chemistry	Total Metals	√		Increased concentrations of Zn and other metals in exposure area in creek. Increased concentrations consistent with benthic effects observed.
	Dissolved Metals	√		Increased concentrations of Zn and other metals in exposure area in creek. Increased concentrations consistent with benthic effects observed.
Sediment Chemistry	Total Metals Partial Metals	√ √		Gradient in exposure area evident for Zn, Cu, Cd, Mo, Ag and As. Some correlations occurred between sediment metals, the benthic community and toxicity. Total metals correlated more strongly with sediment toxicity.
	SEM/AVS		√	SEM/AVS was an ineffective predictor of biological impact and sediment toxicity at the Myra Falls site.
Effluent Toxicity	*Ceriodaphnia*	√		*Ceriodaphnia* responded to effluent exposure. *Ceriodaphnia* was similar in sensitivity and effectiveness to the *Selenastrum* and *Lemna* tests.
	Selenastrum	√		*Selenastrum* responded to effluent exposure. *Selenastrum* was similar in sensitivity and effectiveness to the *Ceriodaphnia* and *Lemna* tests.
	Lemna minor	√		*Lemna* responded to effluent exposure. *Lemna* was similar in sensitivity and effectiveness to the *Selenastrum* and *Ceriodaphnia* tests.
	Fathead minnow		√	Fathead minnow was insensitive to all effluent samples and presented difficulties in acclimation to site water.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT MYRA FALLS

Tool Boxes	Tools	Effectiveness		Comment
		Effect Demonstrated	Effect Not Demonstrated	
Sediment Toxicity	*Hyalella azteca*	√		Effectively responded to near-field conditions. *Hyalella* and *Chironomus* were more sensitive than *Tubifex* in terms of survival and degree of response.
	Chironomus riparius	√		Effectively responded to near-field conditions. *Hyalella* and *Chironomus* were more sensitive than *Tubifex* in terms of survival and degree of response.
	Tubifex tubifex	√		*Tubifex* showed some sublethal responses to exposure (reproductive effects).
Benthic Community Health Indicators	Benthic Density		√	Exposure-reference differences in the creek and lakes were apparent but not significant.
	No. of Taxa		√	Exposure-reference differences not evident in lake or creek.
	No. of EPT Taxa - creek	√		Exposure-reference difference evident in Myra Creek.
	Abundances of Indicator Taxa	√		Exposure-reference differences evident in Myra Creek and in lakes (different indicators in lakes and creek).

TABLE 6.3: COMPARATIVE EFFECTIVENESS OF MONITORING TOOLS AT MYRA FALLS

Tools	Comparison
Total Metals vs Dissolved Metals in Water	Dissolved metal concentrations were similar in effectiveness to total metals in predicting benthic responses in Myra Creek. Assessed qualitatively.
Total Metals, Partial Metals and SEM/AVS in Sediment	Total metals were, on average, slightly better correlated with benthic effects and sediment toxicity than were partial metals. The SEM/AVS ratio was not correlated with benthic effects or sediment toxicity.
Effluent Chronic Toxicity Tests	*Selenastrum, Lemna* and *Ceriodaphnia* tests were generally more sensitive than the fathead minnow test. Fathead minnow test was ineffective.
Sediment Toxicity Tests	*Hyalella* and *Chironomus* test results were more sensitive and better linked with sediment metals and benthic effects than were *Tubifex* test results. However, some reproductive responses in *Tubifex* were effective in showing exposure effects.
Benthic Community Health Indicators (density, no. of taxa, EPT index, indicator taxa)	Abundances of indicator taxa responded effectively to mine effects in both lake and stream environments, although different indicators were effective in lake than in stream habitat. Other indices (total densities, numbers of taxa) were marginally effective or ineffective. The EPT index was effective in Myra Creek.

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APPENDIX 1

Myra Falls Reconnaissance Survey

APPENDIX 1: MYRA FALLS RECONNAISSANCE SURVEY

A brief reconnaissance survey was completed by BEAK/GOLDER at the Myra Falls mine site during the week of 09 June 1997. The reconnaissance was carried out to evaluate:

- the feasibility of benthic, periphyton and fish sampling in Myra Creek;
- the nature of the sediment chemistry gradient in Buttle Lake;
- the feasibility of collecting benthos in deeper (profundal) sediments of Buttle Lake; and
- the occurrence of a strong water chemistry gradient for testing of biological responses to aqueous metal levels (e.g., H9).

Sampling included electrofishing of Myra Creek upstream and downstream of the mine, collection of surficial sediments for assessment of benthic community structure (petite Ponar and 250 μm mesh screen), and collection of water samples in Myra Creek and Buttle Lake (conductivity and total metals). Sampling locations in Myra Creek and Buttle Lake are illustrated in Figure 1. Also, discussions were held with environmental staff at the mine, with the Department of Fisheries and Oceans, with Strathcona Park biologists, and with Dr. John Peterson of the University of British Columbia to collect further detailed insights on local conditions.

Myra Creek

Electrofishing was carried out using a portable backpack-type electrofisher (Smith-Root Model XV) in Myra Creek upstream and downstream of the mine. Approximately two hours of electrofishing effort was carried out in Myra Creek at Stations MC-1, MC-2 and MC-3. No fish were captured and only one was observed. Discussions with mine staff confirmed that some sport fishing occurs in the creek, and fish have been observed in the upper portion of the creek. These results indicate that fish are present in the creek at densities too low for sampling in the 1997 field program. These low densities may be partly due to the barrier created by the falls at the mouth of the creek.

Field reconnaissance staff also noted that periphyton growth was visibly sparse or not evident on rock substrates in Myra Creek. This indicates that periphyton sampling is impractical in Myra Creek.

Water chemistry sampling in Myra Creek (refer to laboratory report and conductivity readings following) show an increase in concentrations of metals, particularly zinc, downstream of the effluent discharge. Concentrations of zinc were 0.27 mg/L in treated effluent, although Myra Falls staff indicated that significant loadings of zinc also occur from seepage losses from the tailings area. This value is unusually high compared to routine sampling values conducted by the mine (S. Janaszwenski, Myra Falls Operation, pers. comm.). Conductivity values in effluent and downstream of the mine imply an effluent concentration of <5% in Myra Creek, with little concentration gradient in the creek downstream of the mine.

CONDUCTIVITY IN MYRA CREEK AND BUTTLE LAKE SURFACE WATER, JUNE 1997

Station	Conductivity (μS)
Myra Creek MC-1 (reference)	10
Myra Creek at tailings dam	45
Treated effluent	800
Myra Creek downstream, MC-2	49
Myra Creek at falls, MC-3	40
Buttle Lake at Myra Creek mouth	35
Buttle Lake Station 3	37
Buttle Lake Station 7	45

Buttle Lake

Buttle Lake sediment chemistry results show a spatial gradient in deeper profundal sediments in terms of zinc, lead and copper (see following laboratory report). Concentrations are somewhat lower at Stations 1 and 2 in proximity to the mouth of Myra Creek where sediments are coarse in texture, but then increase at Stations 3 to 6 and decline at Station 7. All profundal stations sampled (Stations 3 to 7) were in the range of 20 to 55 m in water depth and were soft in texture. Gray tailings material was visibly apparent in samples from Stations 3, 4 and 5. Dr. Peterson of the University of British

Columbia was unable to provide any further detail on the spatial distribution of sediment chemistry in Buttle Lake.

Benthic macroinvertebrate results demonstrated the occurrence of variable but relatively high densities of organisms ($350/m^2$ to $45,913/m^2$), with communities dominated by chironomids, microcrustaceans and oligochaetes (see benthic data tabulation following). This indicates that benthic sampling can be effectively carried out in deep, profundal sediments, and that testing of the sediment triad is feasible in Buttle Lake.

Water quality monitoring by Myra Falls mine staff was carried out at two locations in Buttle Lake on 13 June 1997 - near Karst Creek and near Henshaw Creek. The mine's results of these analyses are appended. Results indicate that, on 13 June, the lake was thermally stratified, and that metal concentrations were relatively low, although they remained above those reported in nearby Upper Quinsam Lake in 1981 (Roch *et al.*, 1982). Total and dissolved zinc and copper concentrations in Buttle Lake were elevated (to 0.07 mg/L Zn, 0.016 mg/L Cu), but remain lower than the 0.1 to 0.2 mg/L values for Zn reported by Roch *et al.* (1982).

Although not sampled in 1997, Upper Quinsam Lake was reported to have very low metal concentrations in 1981, with correspondingly low metal and metallothionein levels in rainbow trout liver (Roch *et al.*, 1982). Interestingly, B.C. Ministry biologist stated that rainbow trout have never been found in Upper Quinsam Lake and recommended that Brewster Lake be used to capture rainbow trout for the program.

TOTAL METAL CONCENTRATIONS IN SURFICIAL SEDIMENTS, BUTTLE LAKE, JUNE 1997

Zenon Environmental Laboratories - Certificate of Analysis

			MC-1	MC-2	MC-3	
	Client ID:		ST1	ST2	ST3	Effluent
	Zenon ID:		023099 97	023100 97	023101 97	023102 97
	Date Sampled:		97/06/14	97/06/14	97/06/14	97/06/14
Component	**MDL**	**Units**				
Aluminum	0.005	mg/L	0.032	0.038	0.036	0.32
Antimony	0.0005	"	<	<	<	0.010
Arsenic	0.002	"	<	<	<	<
Barium	0.005	"	<	<	<	0.031
Beryllium	0.001	"	<	<	<	<
Boron	0.005	"	<	<	<	0.027
Cadmium	0.0001	"	<	0.0002	0.0001	0.0012
Calcium	0.50	"	2.5	10	8.8	190
Chromium	0.005	"	<	<	<	<
Cobalt	0.0001	"	<	0.0001	0.0001	0.0002
Copper	0.0005	"	0.0009	0.004	0.0038	0.0043
Iron	0.06	"	<	<	<	<
Lead	0.0005	"	<	<	<	0.0014
Magnesium	0.050	"	0.11	0.5	0.49	2.9
Manganese	0.005	"	<	0.040	0.034	0.045
Molybdenum	0.001	"	<	<	<	0.033
Nickel	0.001	"	<	<	<	0.005
Phosphorus	0.050	"	<	<	<	0.07
Potassium	0.500	"	0.2	0.3	0.2	9.7
Selenium	0.002	"	<	<	<	0.004
Silicon	0.050	"	0.70	0.93	0.91	1.6
Silver	0.00007	"	<	<	<	<
Sodium	0.100	"	0.6	0.8	0.7	13
Strontium	0.0005	"	0.005	0.030	0.025	0.84
Thallium	0.00005	"	<	<	<	<
Tin	0.001	"	<	<	<	<
Titanium	0.005	"	<	<	<	<
Uranium	0.0001	"	<	<	<	<
Vanadium	0.0005	"	<	<	<	0.0007
Zinc	0.002	"	0.012	0.097	0.088	0.27

Client:Beak International Project:20776.1

Zenon Environmental Laboratories - Certificate of Analysis

Component	MDL	Units	ST1	ST2	ST3	ST4
Zenon ID:			023103 97	023104 97	023105 97	023106 97
Date Sampled:			97/06/14	97/06/14	97/06/14	97/06/14
Aluminum	30	mg/kg	20000	20000	16000	22000
Barium	0.2	"	72	110	610	1100
Beryllium	0.1	"	0.2	0.2	0.1	0.3
Boron	10	"	<	<	<	<
Cadmium	0.2	"	1.5	2.4	13	11
Calcium	20	"	5100	4800	9700	5500
Chromium	5	"	23	20	40	36
Cobalt	5	"	18	16	13	18
Copper	5	"	130	150	770	740
Iron	5	"	41000	39000	53000	48000
Lead	10	"	38	39	600	450
Magnesium	40	"	13000	13000	13000	13000
Manganese	5	"	710	570	730	980
Molybdenum	1	"	2.0	3.0	28	17
Nickel	5	"	18	16	33	26
Phosphorus	50	"	380	390	540	560
Potassium	100	"	490	510	1000	940
Silicon	10	"	200	200	570	470
Silver	0.5	"	<	<	11	6.9
Sodium	50	"	71	73	68	120
Strontium	0.1	"	13	12	60	47
Sulphur	10	"	1300	2000	34000	16000
Thallium	20	"	<	<	<	<
Tin	5	"	<	<	<	<
Titanium	5	"	1300	1100	330	830
Vanadium	10	"	100	88	48	76
Zinc	5	"	320	630	4200	3300
Zirconium	5	"	<	<	<	<

Zenon Environmental Laboratories - Certificate of Analysis

	Client ID:		ST5	ST6	ST7
	Zenon ID:		023107 97	023108 97	023109 97
	Date Sampled:		97/06/14	97/06/14	97/06/14
Component	**MDL**	**Units**			
				(2)	
Aluminum	30	mg/kg	28000	25000	18000
Barium	0.2	"	2400	3000	78
Beryllium	0.1	"	0.4	<0.5	0.3
Boron	10	"	<	<50	<
Cadmium	0.2	"	9.8	7.9	2.6
Calcium	20	"	6200	6600	7300
Chromium	5	"	38	33	27
Cobalt	5	"	25	32	18
Copper	5	"	1500	1300	230
Iron	5	"	64000	64000	30000
Lead	10	"	780	620	65
Magnesium	40	"	13000	11000	6300
Manganese	5	"	4700	17000	510
Molybdenum	1	"	21	16	2.0
Nickel	5	"	27	28	24
Phosphorus	50	"	720	690	480
Potassium	100	"	1100	950	390
Silicon	10	"	370	500	230
Silver	0.5	"	9.8	6.2	<
Sodium	50	"	180	270	200
Strontium	0.1	"	49	50	15
Sulphur	10	"	2200	1400	830
Thallium	20	"	<	<100	<
Tin	5	"	<	<25	<
Titanium	5	"	1000	1200	1800
Vanadium	10	"	96	94	100
Zinc	5	"	2800	2300	590
Zirconium	5	"	<	<25	<

BENTHIC MACROINVERTEBRATE SPECIES AND DENSITIES IN BUTTLE LAKE, JUNE 1997

TABLE 1: BENTHIC INVERTEBRATES FROM MYRA FALLS, B.C., JUNE 1997. (density expressed per m2).

Station	2	3	4	5	6	7
WATER DEPTH (Ft)	20'	180'	160'	110'	140'	60'
P. Nematoda	4522	783	87	-	609	-
P. Annelida						
Cl. Oligochaeta	9739	1478	696	87	43	43
P. Arthropoda						
Cl. Arachnida						
O. Hydracarina	-	43	43	43	43	43
Cl. Maxillopoda						
O. Harpacticoida	4870	87	-	87	-	-
Cl. Ostracoda	2783	783	-	-	43	1130
Cl. Insecta						
O. Trichoptera						
F. Leptoceridae						
Mystacides	522	-	-	-	-	87
O. Diptera						
F. Chironomidae						
Chironomid pupae	522	-	-	-	-	87
S.F. Chironominae						
Chironomus	-	43	43	-	-	-
?Cladopelma	-	-	-	-	-	174
Cladotanytarsus	2609	-	-	-	-	522
Dicrotendipes	9739	-	-	-	-	43
Micropsectra	-	87	-	-	-	-
Microtendipes	-	-	-	-	-	43
Pagastiella	174	-	-	-	-	-
?Paracladopelma	174	-	-	-	-	-
Paratendipes	174	174	-	-	-	-
Polypedilum	174	-	-	-	-	43
Sergentia	-	43	43	-	-	-
Tanytarsus	2087	87	-	-	-	43
S.F. Diamesinae						
Protanypus	-	-	-	43	-	-
S.F. Orthocladiinae						
indeterminate	2261	-	-	-	-	-
Heterotrissocladius	-	-	-	-	739	174
Zalutschia	-	-	43	87	261	739
S.F. Tanypodinae						
Ablabesmyia	348	-	-	-	-	-
Procladius	5043	87	-	-	-	435
F. Empididae						
Chelifera	174	-	-	-	-	-
P. Mollusca						
Cl. Gastropoda						
indeterminate	-	-	-	-	-	43
Cl. Pelecypoda						
F. Sphaeriidae						
Pisidium	-	-	130	-	-	174
TOTAL NUMBER OF ORGANISMS	45913	3696	1087	348	1739	3826
TOTAL NUMBER OF TAXA	16	11	7	5	6	15

WATER QUALITY CONDITIONS IN
BUTTLE LAKE, JUNE 1997
DATA PROVIDED BY WESTMIN RESOURCES

BUTTLE LAKE AT KARST CREEK **SEAM Site 0130090**
DEPTH PROFILE
PERMIT PE-6858

Date: June 13/97

DEPTH m	TEMP C	D-O2 mg/l	pH	SPCOND mmhos/cm
00	13.32	11.31	7.45	0.064
05	11.89	12.03	7.57	0.066
10	10.33	12.16	7.53	0.061
15	8.22	12.17	7.48	0.066
20	6.84	12.25	7.41	0.069
25	5.96	12.28	7.38	0.072
30	5.59	12.22	7.37	0.073
35	5.41	12.11	7.35	0.072
40	5.3	12.13	7.34	0.072
45	5.17	12.12	7.32	0.071
50	5.13	12.08	7.32	0.072

SEAM Site 0130082

BUTTLE LAKE AT HENSHAW CREEK
DEPTH PROFILE - HYDROLAB / SOND UNIT
PERMIT PE-6858

Date: June 13/97

DEPTH m	TEMP C	D-O2 mg/l	pH	SPCOND mmhos/cm
00	13.04	11.93	7.62	0.064
05	11.98	11.97	7.48	0.064
10	10.37	12.05	7.41	0.061
15	9.10	12.15	7.33	0.057
20	7.70	12.26	7.27	0.060
25	6.96	12.26	7.24	0.065
30	6.13	12.12	7.20	0.073
35	5.60	12.05	7.17	0.082
40	5.35	11.93	7.15	0.084
45	5.26	11.90	7.14	0.086
50	5.21	11.92	7.13	0.085

RESULTS OF ANALYSIS - Water

File No. H4281

			KARST Buttle Lk. 0m 97 06 13	KARST Buttle Lk. 20m 97 06 13	KARST Buttle Lk. 40m 97 06 13	KARST Buttle Lk. 60m 97 06 13
Physical Tests						
Hardness	CaCO3		-	-	-	-
Total Suspended Solids			<1	1	<1	<1
Turbidity	(NTU)		0.2	0.3	0.4	0.2
Dissolved Anions						
Alkalinity-Total	CaCO3		-	-	-	-
Silicate	SiO2		3	3	3	3
Sulphate	SO4		4	7	6	6
Nutrients						
Ammonia Nitrogen		N	0.008	<0.005	0.009	<0.005
Total Kjeldahl Nitrogen		N	-	-	-	-
Total Nitrogen		N	-	-	-	-
Nitrite/Nitrate Nitrogen		N	0.020	0.040	0.043	0.045
Total Dissolved Phosphate		P	0.001	0.001	0.002	0.002
Total Phosphate		P	0.001	0.002	0.002	0.002
Total Metals						
Aluminum	T-Al		0.027	0.020	0.015	0.013
Cadmium	T-Cd		<0.0002	<0.0002	<0.0002	<0.0002
Calcium	T-Ca		9.11	10.0	10.4	10.3
Copper	T-Cu		0.002	0.002	0.002	0.002
Iron	T-Fe		<0.03	<0.03	<0.03	<0.03
Lead	T-Pb		<0.001	<0.001	<0.001	<0.001
Manganese	T-Mn		<0.005	<0.005	<0.005	<0.005
Zinc	T-Zn		0.017	0.025	0.019	0.019
Dissolved Metals						
Aluminum	D-Al		0.015	0.015	0.011	0.012
Cadmium	D-Cd		<0.0002	<0.0002	<0.0002	<0.0002
Calcium	D-Ca		8.97	9.47	10.3	9.93
Copper	D-Cu		0.002	0.001	0.001	0.001
Iron	D-Fe		<0.03	<0.03	<0.03	<0.03
Lead	D-Pb		<0.001	<0.001	<0.001	<0.001
Magnesium	D-Mg		-	-	-	-
Manganese	D-Mn		<0.005	<0.005	<0.005	<0.005
Zinc	D-Zn		0.014	0.023	0.018	0.020

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. H4281

RESULTS OF ANALYSIS - Water

			KARST Buttle Lk. 100m 97 06 13	Buttle Lk. Hen 0m 97 06 13	Buttle Lk. Hen 10m 97 08 13	Buttle Lk. Hen 20m 97 06 13
Physical Tests						
Hardness	CaCO3		-	-	-	-
Total Suspended Solids			<1	<1	<1	<1
Turbidity	(NTU)		0.3	0.6	0.7	0.6
Dissolved Anions						
Alkalinity-Total		CaCO3	-	-	-	-
Silicate	SiO2		3	2	3	2
Sulphate	SO4		6	6	5	7
Nutrients						
Ammonia Nitrogen		N	<0.005	0.007	0.008	0.005
Total Kjeldahl Nitrogen		N	-	-	-	-
Total Nitrogen		N	-	-	-	-
Nitrite/Nitrate Nitrogen		N	0.046	0.021	0.019	0.025
Total Dissolved Phosphate		P	0.001	<0.001	0.001	0.002
Total Phosphate		P	0.002	0.002	0.001	0.002
Total Metals						
Aluminum	T-Al		0.015	0.019	0.032	0.040
Cadmium	T-Cd		<0.0002	<0.0002	<0.0002	<0.0002
Calcium	T-Ca		10.2	9.16	8.21	8.19
Copper	T-Cu		0.002	0.002	0.003	0.008
Iron	T-Fe		<0.03	<0.03	<0.03	<0.03
Lead	T-Pb		<0.001	<0.001	<0.001	<0.001
Manganese	T-Mn		<0.005	<0.005	0.005	0.006
Zinc	T-Zn		0.020	0.013	0.024	0.032
Dissolved Metals						
Aluminum	D-Al		0.014	0.021	0.038	0.076
Cadmium	D-Cd		<0.0002	<0.0002	<0.0002	<0.0002
Calcium	D-Ca		10.0	9.00	8.24	8.08
Copper	D-Cu		0.002	0.002	0.002	0.002
Iron	D-Fe		<0.03	<0.03	<0.03	<0.03
Lead	D-Pb		<0.001	<0.001	<0.001	<0.001
Magnesium	D-Mg		-	-	-	-
Manganese	D-Mn		<0.005	<0.005	<0.005	<0.005
Zinc	D-Zn		0.020	0.014	0.026	0.039

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

			Buttle Lk. Hen 40m 97 06 13	Buttle Lk. Hen 60m 97 06 13
Physical Tests				
Hardness	CaCO3		-	-
Total Suspended Solids			<1	<1
Turbidity	(NTU)		0.5	0.7
Dissolved Anions				
Alkalinity-Total		CaCO3	-	-
Silicate	SiO2		3	3
Sulphate	SO4		13	14
Nutrients				
Ammonia Nitrogen		N	<0.005	0.007
Total Kjeldahl Nitrogen		N	-	-
Total Nitrogen		N	-	-
Nitrite/Nitrate Nitrogen		N	0.054	0.059
Total Dissolved Phosphate		P	<0.001	0.001
Total Phosphate		P	0.002	0.001
Total Metals				
Aluminum	T-Al		0.037	0.037
Cadmium	T-Cd		<0.0002	<0.0002
Calcium	T-Ca		11.8	12.8
Copper	T-Cu		0.016	0.016
Iron	T-Fe		<0.03	<0.03
Lead	T-Pb		<0.001	<0.001
Manganese	T-Mn		0.008	0.011
Zinc	T-Zn		0.064	0.071
Dissolved Metals				
Aluminum	D-Al		0.155	0.061
Cadmium	D-Cd		<0.0002	<0.0002
Calcium	D-Ca		12.2	12.3
Copper	D-Cu		0.003	0.004
Iron	D-Fe		<0.03	<0.03
Lead	D-Pb		<0.001	0.001
Magnesium	D-Mg		-	-
Manganese	D-Mn		<0.005	<0.005
Zinc	D-Zn		0.070	0.071

Remarks regarding the analyses appear at the beginning of this r
Results are expressed as milligrams per litre except where noted.
< - Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

File No. H4281

	Buttle Lk.@ Karst Ck 97 06 13
Organic Parameters	
Chlorophyll	0.07

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

File No. H4281

	Buttle Lk. @ Henshaw 97 06 13
Organic Parameters	
Chlorophyll	<0.04

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

APPENDIX 2

Quality Assurance/Quality Control

BEAK MEMO

To: **Paul McKee, Project Manager**
Dennis Farara, Project Manager

From: Guy Gilron, QA Officer
Pierre Stecko, QA Officer

Ref: **AETE 1997 - Myra Falls Mine Data QA Report**

Date: May 15, 1998

We have reviewed the 1997 AETE data collected from the Myra Falls mine and have conducted a data quality assessment in comparison to the data quality objectives (DQO) outlined in the Quality Management Plan (QMP). A summary of the results of the data quality assessment is presented below, categorized by study.

Benthos (Table A2.1)

DQOs for percent recovery (≥ 95%) were met, based on samples MCR3, MCE7, MR1 and MN6. **FLAG:** Laboratory precision (≥ 80%) was met for sample MF4, but was not met for sample MR2 (67.4%).

Water Chemistry - Conventional and Aggregate Parameters (Table A1.2)

Trip, field and filter blanks met DQOs in all cases. There were no DQOs set for laboratory precision for water chemistry. However, we have flagged parameters with >50% difference (as a percentage of the mean). No such differences occurred between laboratory replicate samples. **FLAGS:** Differences of greater than 50% between field duplicates were observed for ion balance (MCR1, MN7), dissolved organic carbon (MN7).

Water Chemistry - Metals and Nutrients (Table A1.2)

Trip, field and filter blanks met specified DQOs. However, detectable concentrations of copper and zinc occurred in the blanks (up to 4.9 and 6 μg/L, respectively), suggesting that some contribution of these metals from the deionized water or from the fixing or analysis reagents may have occurred. In addition, none of the metals and nutrients exhibited differences greater than 50% between laboratory replicates.

However, some differences greater than 50% were observed between field duplicates. **FLAGS:** Boron (MCR1), copper (MN7), molybdenum (MN7), zinc (MN7).

Sediment

a) Total Metals (Table A2.3)

Recovery of total metals in matrix spikes varied from 79 to 110%, while the DQO for laboratory accuracy was 10% (i.e., 90 to 110% recovery). **FLAGS:** Beryllium (MF3; 89%), boron (MF3 [81%], MN9 [81%] and MR1 [79%]) and nickel (MF3; 89%). In addition, antimony (MF3), selenium (MF3 and MN9), strontium (MF3), tin (MN9), cadmium (MR1) and molybdenum (MR1) exceeded the DQO for laboratory precision (10%).

b) Partial Extraction (Table A2.4)

No metals exceeded the DQO for laboratory precision (10%). Recovery of metals extracted with NH_2OH-HCl in 25% (v/v) acetic acid in matrix spikes of sample MF4 varied from 71 to 110%, while the DQO for laboratory accuracy was 10% (i.e., 90 to 110% recovery). **FLAGS:** Boron (MF3 [85%]; MN9 [84%]; MR1[83%]), lead (MN9; 71%), manganese (MN9; 76%), zinc (MN9; 85%).

c) Simultaneously Extracted Metals (Table A2.5)

The concentration of metals extracted with the acid volatile sulphides was assessed in three samples and compared to DQOs for laboratory precision (10%). **FLAGS:** For the key metals, the following are flagged: cadmium (MF2), lead (MF2) and zinc (MF3, MN9). In addition, the estimate of SEM to AVS is flagged at MF2.

There are a number of potential sources of variability in the SEM/AVS extraction. First, the method uses a wet extraction, therefore variability can easily be introduced in sub-sampling for the estimate of the wet/dry ratio (i.e., if a particularly wet sub-sample is taken, metals concentration of a dry weight basis will be overestimated). In addition, the SEM/AVS technique is very redox sensitive, and small scale variability could significantly influence the comparability of sub-samples.

d) Comparisons of Metal Concentrations in Different Extracts

The amount of metal mobilized by the different extractants was checked for discrepancies. Total metals were assessed using a nitric acid and peroxide mix. To determine the comparability to Canadian Sediment Quality Guidelines (which are developed for metals extracted with aqua regia), some samples were extracted with aqua regia for comparison. The two methods compared well (Table A2.6), and no significant differences were flagged. Concentrations removed by the partial extraction were always lower than those removed by the aqua regia and total extraction, consistent with the weaker nature of the extractant used. There were some inconsistencies in the comparison of simultaneously extracted metals and total metals (i.e., SEM were often greater than total metals; Table A2.7). As discussed above, this may be the result of the wet weight to dry weight conversion.

Water Toxicity (Table A2.8)

All DQOs for water toxicity (i.e., minimum significant difference, control mortality, control and reference toxicant variability; and accuracy of the reference toxicant) were achieved. **NO FLAGS.**

Sediment Toxicity (Table A2.9)

There were no DQOs specified for sediment toxicity. However, we reviewed control mortality, coefficients of variation for the controls, coefficients of variation for the re-tests, and the reference toxicant results (control charts) and there were no deviations of concern. **NO FLAGS.**

Table A2.1: Results of Benthic Sorting Recovery Check and Subsampling Checks, Myra Falls

Station	Number of Animals Recovered	Number of Animals in Re-sort	Percent Recovery
MCR3	830	22	97.4
MCE7	342	13	96.3
MR1	81	3	96.4
MN6	115	1	99.1

CALCULATION OF SUBSAMPLING ERROR FOR BENTHIC INVERTEBRATE SAMPLES FROM MYRA FALLS

Station	Number of Animals in Fraction 1	Number of Animals in Fraction 2	Standard Deviation	Coefficient of Variation
MR2	96	60	25.46	32.64
MF4	55	50	3.54	6.73

SAMPLES THAT REQUIRED SUBSAMPLING FOR MYRA FALLS

Station	Fraction Sorted
MR1	1/2
MR2	1/2*
MR3	1/2
MR4	1/2
MR5	1/2
MR6	1/2
MR7	1/2
MN5	1/2
MN6	1/2
MN7	1/2
MN9	1/2
MN10	1/2
MF1	1/2
MF2	1/2
MF3	1/2
MF4	1/2*
MF5	1/2
MF6	1/2
MF7	1/2

* additional 1/2 sorted for subsampling error

Table A2.2: Myra Falls Water Chemistry QA/QC

Analysis of Water			EXPOSURE STATIONS								
Parameter	LOQ	Units	MCE1-W Total	MCE1-W Total Lab Rep	**DQA (%diff) vs. LR**	MCE1-W Dissolved	MCE1-W Dissolved Lab Rep	**DQA (%diff) vs. LR**	MCE10-W Total	MCE10-W Total Lab Rep	**DQA (%diff) vs. LR**
Acidity(as CaCO3)	1	mg/L	8	6	**28.57**	-	-	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	15	14	**6.90**	-	-	-	-	-	-
Aluminum	0.005	mg/L	0.054	-	-	0.043	0.041	**4.76**	0.053	-	-
Ammonia(as N)	0.05	mg/L	0.08	0.09	**11.76**	-	-	-	-	-	-
Anion Sum	na	meq/L	2.25	-	-	-	-	-	-	-	-
Antimony	0.0005	mg/L	nd	-	-	nd	nd	-	nd	-	-
Arsenic	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Barium	0.005	mg/L	0.011	-	-	0.01	0.01	**0.00**	0.01	-	-
Beryllium	0.005	mg/L	nd	-	-	nd	nd	-	nd	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	15	-	-	-	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Boron	0.005	mg/L	0.01	0.01	**0.00**	nd	nd	-	0.012	-	-
Cadmium	0.00005	mg/L	0.00057	-	-	0.00053	0.00053	**0.00**	0.00056	-	-
Calcium	0.1	mg/L	34.6	35	**1.15**	38	37.8	**0.53**	33.2	-	-
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	-	-	-	-	-
Cation Sum	na	meq/L	2.22	-	-	-	-	-	-	-	-
Chloride	1	mg/L	2	2	**0.00**	-	-	-	-	-	-
Chromium	0.0005	mg/L	nd	-	-	0.0005	0.0005	**0.00**	nd	-	-
Cobalt	0.0002	mg/L	0.0006	-	-	0.0005	0.0006	**18.18**	0.0006	-	-
Colour	5	TCU	nd	nd	-	-	-	-	-	-	-
Conductivity - @25oC	1	us/cm	220	220	**0.00**	-	-	-	-	-	-
Copper	0.0003	mg/L	0.0104	-	-	0.0075	0.0078	**3.92**	0.0103	-	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	2.7	2.3	**16.00**	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	0.8	na	-	-	-	-
Hardness(as CaCO3)	0.1	mg/L	102	-	-	-	-	-	-	-	-
Ion Balance	0.01	%	0.75	-	-	-	-	-	-	-	-
Iron	0.02	mg/L	0.04	-	-	0.04	0.04	**0.00**	0.04	-	-
Langelier Index at 20oC	na	na	-1.3	-	-	-	-	-	-	-	-
Langelier Index at 4oC	na	na	-1.7	-	-	-	-	-	-	-	-
Lead	0.0001	mg/L	nd	-	-	0.0006	0.0005	**18.18**	nd	-	-
Magnesium	0.1	mg/L	1.6	1.6	**0.00**	1.7	1.7	**0.00**	1.6	-	-
Manganese	0.0005	mg/L	0.192	-	-	0.178	0.181	**1.67**	0.19	-	-
Mercury (total)	0.0001	mg/L	nd	-	-	-	-	-	nd	nd	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-	-	-	-
Molybdenum	0.0001	mg/L	0.0036	-	-	0.0036	0.0035	**2.82**	0.0034	-	-
Nickel	0.001	mg/L	0.002	-	-	0.002	0.002	**0.00**	0.002	-	-
Nitrate(as N)	0.05	mg/L	0.19	0.19	**0.00**	-	-	-	-	-	-
Nitrite(as N)	0.01	mg/L	0.01	0.01	**0.00**	-	-	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-	-	-	-
pH	0.1	Units	7.4	7.5	**1.34**	-	-	-	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Phosphorus, Total	0.01	mg/L	0.02	0.02	**0.00**	-	-	-	-	-	-
Potassium	0.5	mg/L	0.8	1.1	**31.58**	1.6	1.4	**13.33**	1	-	-
Reactive Silica(SiO2)	0.5	mg/L	3	3.1	**3.28**	-	-	-	-	-	-
Saturation pH at 20oC	na	units	8.69	-	-	-	-	-	-	-	-
Saturation pH at 4oC	na	units	9.09	-	-	-	-	-	-	-	-
Selenium	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Silver	0.00005	mg/L	nd	-	-	nd	nd	-	nd	-	-
Sodium	0.1	mg/L	2.9	2.9	**0.00**	3.1	3.1	**0.00**	2.8	-	-
Strontium	0.005	mg/L	0.131	-	-	0.125	0.126	**0.80**	0.124	-	-
Sulphate	2	mg/L	90	90	**0.00**	-	-	-	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	nd	-	nd	-	-
Tin	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Titanium	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	150	-	-	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.12	0.1	**18.18**	-	-	-	-	-	-
Total Suspended Solids	1	mg/L	nd	nd	-	-	-	-	-	-	-
Turbidity	0.1	NTU	0.3	0.3	**0.00**	-	-	-	-	-	-
Uranium	0.0001	mg/L	nd	-	-	nd	nd	-	nd	-	-
Vanadium	0.002	mg/L	nd	-	-	nd	nd	-	nd	-	-
Zinc	0.001	mg/L	0.372	-	-	0.369	0.356	**3.59**	0.367	-	-
Fluoride	0.02	mg/L	nd	nd	-	-	-	-	-	-	-

Table A2.2: Myra Falls Water Chemistry QA/QC

Analysis of Water			EXPOSURE STATIONS					
Parameter	LOQ	Units	MCR1-W Total	MCR1-W Total Field Dup	**DQA (%diff) vs. FD**	MCR1-W Dissolved	MCR1-W Dissolved Field Dup	**DQA (%diff) vs. FD**
Acidity(as CaCO3)	1	mg/L	2	2	**0.00**	-	-	-
Alkalinity(as CaCO3)	1	mg/L	13	12	**8.00**	-	-	-
Aluminum	0.005	mg/L	0.023	0.024	**4.26**	0.022	0.023	**4.44**
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	-	-
Anion Sum	na	meq/L	0.301	0.281	**6.87**	-	-	-
Antimony	0.0005	mg/L	nd	nd	-	nd	nd	-
Arsenic	0.002	mg/L	nd	nd	-	nd	nd	-
Barium	0.005	mg/L	nd	nd	-	nd	nd	-
Beryllium	0.005	mg/L	nd	nd	-	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	13	12	**8.00**	-	-	-
Bismuth	0.002	mg/L	nd	nd	-	nd	nd	-
Boron	0.005	mg/L	0.012	0.031	**88.37**	nd	nd	-
Cadmium	0.00005	mg/L	nd	nd	-	nd	nd	-
Calcium	0.1	mg/L	4.5	4.5	**0.00**	4.8	4.8	**0.00**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	-	-
Cation Sum	na	meq/L	0.274	0.276	**0.73**	-	-	-
Chloride	1	mg/L	nd	nd	-	-	-	-
Chromium	0.0005	mg/L	nd	nd	-	nd	nd	-
Cobalt	0.0002	mg/L	nd	nd	-	nd	nd	-
Colour	5	TCU	nd	nd	-	-	-	-
Conductivity - @25øC	1	us/cm	27	27	**0.00**	-	-	-
Copper	0.0003	mg/L	nd	nd	-	0.0008	0.0008	**0.00**
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	1.8	1.5	**18.18**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	0.8	0.9	**11.76**
Hardness(as CaCO3)	0.1	mg/L	12.7	12.8	**0.78**	-	-	-
Ion Balance	0.01	%	4.64	0.88	**136.23**	-	-	-
Iron	0.02	mg/L	0.03	0.03	**0.00**	0.03	0.03	**0.00**
Langelier Index at 20øC	na	na	-1.8	-1.89	**4.88**	-	-	-
Langelier Index at 4øC	na	na	-2.2	-2.29	**4.01**	-	-	-
Lead	0.0001	mg/L	nd	nd	-	nd	nd	-
Magnesium	0.1	mg/L	0.2	0.2	**0.00**	0.2	0.2	**0.00**
Manganese	0.0005	mg/L	nd	nd	-	nd	nd	-
Mercury (total)	0.0001	mg/L	nd	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	0.0003	0.0003	**0.00**	0.0003	0.0003	**0.00**
Nickel	0.001	mg/L	nd	nd	-	nd	nd	-
Nitrate(as N)	0.05	mg/L	nd	nd	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-
pH	0.1	Units	7.8	7.8	**0.00**	-	-	-
Phosphorus	0.1	mg/L	-	-	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	nd	0.01	-	-	-	-
Potassium	0.5	mg/L	nd	nd	-	nd	nd	-
Reactive Silica(SiO2)	0.5	mg/L	2	2	**0.00**	-	-	-
Saturation pH at 20øC	na	units	9.62	9.65	**0.31**	-	-	-
Saturation pH at 4øC	na	units	10	10	**0.00**	-	-	-
Selenium	0.002	mg/L	nd	nd	-	nd	nd	-
Silver	0.00005	mg/L	nd	nd	-	nd	nd	-
Sodium	0.1	mg/L	0.5	0.6	**18.18**	0.4	0.4	**0.00**
Strontium	0.005	mg/L	0.009	0.009	**0.00**	0.009	0.009	**0.00**
Sulphate	2	mg/L	nd	nd	-	-	-	-
Thallium	0.0001	mg/L	nd	nd	-	nd	nd	-
Tin	0.002	mg/L	nd	nd	-	nd	nd	-
Titanium	0.002	mg/L	nd	nd	-	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	17	17	**0.00**
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	nd	-	-	-	-
Total Suspended Solids	1	mg/L	1	nd	-	-	-	-
Turbidity	0.1	NTU	0.2	0.2	**0.00**	-	-	-
Uranium	0.0001	mg/L	nd	nd	-	nd	nd	-
Vanadium	0.002	mg/L	nd	nd	-	nd	nd	-
Zinc	0.001	mg/L	nd	nd	-	0.004	0.004	**0.00**
Fluoride	0.02	mg/L	nd	nd	-	-	-	-

Table A2.2: Myra Falls Water Chemistry QA/QC

Analysis of Water			EXPOSURE STATIONS							
Parameter	LOQ	Units	MN7-W Total	MN7-W Total Lab Rep	DQA (%diff) vs. LR	MN7-W Total Field Dup	DQA (%diff) vs. FD	MN7-W Dissolved	MN7-W Dissolved Field Dup	DQA (%diff) vs. FD
Acidity(as CaCO3)	1	mg/L	4	-	-	4	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	23	-	-	22	-	-	-	-
Aluminum	0.005	mg/L	0.02	0.02	**0.00**	0.018	**10.53**	0.013	0.014	**7.41**
Ammonia(as N)	0.05	mg/L	nd	-	-	nd	-	-	-	-
Anion Sum	na	meq/L	0.655	-	-	0.622	**5.17**	-	-	-
Antimony	0.0005	mg/L	nd	nd	-	nd	-	nd	nd	-
Arsenic	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Barium	0.005	mg/L	0.007	0.007	**0.00**	0.006	**15.38**	0.007	0.007	**0.00**
Beryllium	0.005	mg/L	nd	nd	-	nd	-	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	23	-	-	22	**4.44**	-	-	-
Bismuth	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Boron	0.005	mg/L	nd	-	-	0.016	-	nd	nd	-
Cadmium	0.00005	mg/L	0.00007	0.00007	**0.00**	0.00006	**15.38**	0.00006	0.00006	**0.00**
Calcium	0.1	mg/L	9.8	-	-	10	-	10.9	10.6	**2.79**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	nd	-	-	-	-
Cation Sum	na	meq/L	0.626	-	-	0.619	**1.12**	-	-	-
Chloride	1	mg/L	nd	-	-	nd	-	-	-	-
Chromium	0.0005	mg/L	nd	nd	-	nd	-	0.0007	0.0007	**0.00**
Cobalt	0.0002	mg/L	nd	nd	-	nd	-	nd	nd	-
Colour	5	TCU	nd	-	-	nd	-	-	-	-
Conductivity - @25øC	1	us/cm	61	-	-	59	**3.33**	-	-	-
Copper	0.0003	mg/L	0.0014	0.0014	**0.00**	0.0014	**0.00**	0.0034	0.0019	**56.60**
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	-	-	4	3.8	**5.13**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	-	-	1.2	0.5	**82.35**
Hardness(as CaCO3)	0.1	mg/L	30	-	-	29.4	**2.02**	-	-	-
Ion Balance	0.01	%	2.23	-	-	0.28	**155.38**	-	-	-
Iron	0.02	mg/L	0.03	0.04	**28.57**	0.03	**28.57**	0.04	0.03	**28.57**
Langelier Index at 20øC	na	na	-1.32	-	-	-1.25	**5.45**	-	-	-
Langelier Index at 4øC	na	na	-1.72	-	-	-1.65	**4.15**	-	-	-
Lead	0.0001	mg/L	nd	nd	-	nd	-	nd	nd	-
Magnesium	0.1	mg/L	0.6	-	-	0.7	-	0.7	0.7	**0.00**
Manganese	0.0005	mg/L	0.0046	0.0045	**2.20**	0.004	**11.76**	0.0012	0.0009	**28.57**
Mercury (total)	0.0001	mg/L	nd	-	-	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	0.0004	0.0003	**28.57**	0.0003	**0.00**	0.0003	0.0005	**50.00**
Nickel	0.001	mg/L	nd	nd	-	nd	-	nd	nd	-
Nitrate(as N)	0.05	mg/L	0.07	-	-	0.06	**15.38**	-	-	-
Nitrite(as N)	0.01	mg/L	nd	-	-	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	-	-	nd	-	-	-	-
pH	0.1	Units	7.7	-	-	7.8	**1.29**	-	-	-
Phosphorus	0.1	mg/L	-	-	-	-	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	nd	nd	-	nd	-	-	-	-
Potassium	0.5	mg/L	nd	-	-	nd	-	nd	nd	-
Reactive Silica(SiO2)	0.5	mg/L	2.8	-	-	2.8	**0.00**	-	-	-
Saturation pH at 20øC	na	units	9.02	-	-	9.05	**0.33**	-	-	-
Saturation pH at 4øC	na	units	9.42	-	-	9.45	**0.32**	-	-	-
Selenium	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Silver	0.00005	mg/L	nd	nd	-	nd	-	nd	nd	-
Sodium	0.1	mg/L	0.7	-	-	0.8	-	0.6	0.6	**0.00**
Strontium	0.005	mg/L	0.017	0.017	**0.00**	0.016	**6.06**	0.017	0.016	**6.06**
Sulphate	2	mg/L	8	-	-	8	**0.00**	-	-	-
Thallium	0.0001	mg/L	nd	nd	-	nd	-	nd	nd	-
Tin	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Titanium	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	-	-	38	37	**2.67**
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	-	-	nd	-	-	-	-
Total Suspended Solids	1	mg/L	nd	-	-	nd	-	-	-	-
Turbidity	0.1	NTU	0.2	-	-	0.2	**0.00**	-	-	-
Uranium	0.0001	mg/L	nd	nd	-	nd	-	nd	nd	-
Vanadium	0.002	mg/L	nd	nd	-	nd	-	nd	nd	-
Zinc	0.001	mg/L	0.031	0.031	**0.00**	0.028	**10.17**	0.033	0.079	**82.14**
Fluoride	0.02	mg/L	nd	-	-	nd	-	-	-	-

Table A2.2: Myra Falls Water Chemistry QA/QC

Analysis of Water			REFERENCE STATIONS					
Parameter	LOQ	Units	MR1-W Total	MR1-W Total Lab Rep	**DQA (%diff) vs. LR**	MR1-W Dissolved	MR1-W Dissolved Lab Rep	**DQA (%diff) vs. LR**
Acidity(as CaCO3)	1	mg/L	6	6	**0.00**	-	-	-
Alkalinity(as CaCO3)	1	mg/L	10	10	**0.00**	-	-	-
Aluminum	0.005	mg/L	0.062	-	-	0.054	0.055	**1.83**
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	-	-
Anion Sum	na	meq/L	0.236	-	-	-	-	-
Antimony	0.0005	mg/L	nd	-	-	nd	nd	-
Arsenic	0.002	mg/L	nd	-	-	nd	nd	-
Barium	0.005	mg/L	nd	-	-	nd	nd	-
Beryllium	0.005	mg/L	nd	-	-	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	9	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	nd	-
Boron	0.005	mg/L	0.011	0.01	**9.52**	nd	nd	-
Cadmium	0.00005	mg/L	nd	-	-	nd	nd	-
Calcium	0.1	mg/L	3.3	3.2	**3.08**	3.4	3.4	**0.00**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	-	-
Cation Sum	na	meq/L	0.251	-	-	-	-	-
Chloride	1	mg/L	nd	nd	-	-	-	-
Chromium	0.0005	mg/L	nd	-	-	nd	nd	-
Cobalt	0.0002	mg/L	nd	-	-	nd	nd	-
Colour	5	TCU	20	20	**0.00**	-	-	-
Conductivity - @25øC	1	us/cm	26	27	**3.77**	-	-	-
Copper	0.0003	mg/L	0.0011	-	-	0.0016	0.0016	**0.00**
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	1.4	1.4	**0.00**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	5.4	5.7	**5.41**
Hardness(as CaCO3)	0.1	mg/L	10.9	-	-	-	-	-
Ion Balance	0.01	%	3.15	-	-	-	-	-
Iron	0.02	mg/L	0.04	-	-	0.02	0.02	**0.00**
Langelier Index at 20øC	na	na	-2.91	-	-	-	-	-
Langelier Index at 4øC	na	na	-3.31	-	-	-	-	-
Lead	0.0001	mg/L	nd	-	-	nd	nd	-
Magnesium	0.1	mg/L	0.6	0.6	**0.00**	0.6	0.6	**0.00**
Manganese	0.0005	mg/L	0.0011	-	-	0.0005	0.0005	**0.00**
Mercury (total)	0.0001	mg/L	nd	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	nd	-	-	nd	nd	-
Nickel	0.001	mg/L	nd	-	-	nd	nd	-
Nitrate(as N)	0.05	mg/L	0.11	0.11	**0.00**	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-
pH	0.1	Units	7	7.3	**4.20**	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	0.01	0.01	**0.00**	-	-	-
Potassium	0.5	mg/L	nd	nd	-	nd	nd	-
Reactive Silica(SiO2)	0.5	mg/L	4.6	4.6	**0.00**	-	-	-
Saturation pH at 20øC	na	units	9.91	-	-	-	-	-
Saturation pH at 4øC	na	units	10.3	-	-	-	-	-
Selenium	0.002	mg/L	nd	-	-	nd	nd	-
Silver	0.00005	mg/L	nd	-	-	nd	nd	-
Sodium	0.1	mg/L	0.8	0.7	**13.33**	0.7	0.7	**0.00**
Strontium	0.005	mg/L	0.006	-	-	0.006	0.006	**0.00**
Sulphate	2	mg/L	nd	nd	-	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	nd	-
Tin	0.002	mg/L	nd	-	-	nd	nd	-
Titanium	0.002	mg/L	nd	-	-	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	17	-	-	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.07	0.09	**25.00**	-	-	-
Total Suspended Solids	1	mg/L	nd	nd	-	-	-	-
Turbidity	0.1	NTU	0.2	0.2	**0.00**	-	-	-
Uranium	0.0001	mg/L	nd	-	-	nd	nd	-
Vanadium	0.002	mg/L	nd	-	-	nd	nd	-
Zinc	0.001	mg/L	0.002	-	-	0.004	0.005	**22.22**
Fluoride	0.02	mg/L	nd	nd	-	-	-	-

Table A2.2: Myra Falls Water Chemistry QA/QC

Analysis of Water			BLANKS			
Parameter	LOQ	Units	Trip Blank	Field Blank MB-W Total	Filter Blank MR100-W	Filter Blank MR200-W
Acidity(as CaCO3)	1	mg/L	2	6	-	-
Alkalinity(as CaCO3)	1	mg/L	nd	nd	-	-
Aluminum	0.005	mg/L	nd	nd	0.007	0.007
Ammonia(as N)	0.05	mg/L	nd	nd	-	-
Anion Sum	na	meq/L	0	0.005	-	-
Antimony	0.0005	mg/L	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-
Bismuth	0.002	mg/L	nd	nd	nd	nd
Boron	0.005	mg/L	nd	0.007	nd	nd
Cadmium	0.00005	mg/L	nd	nd	nd	nd
Calcium	0.1	mg/L	nd	nd	nd	nd
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-
Cation Sum	na	meq/L	0.001	0.018	-	-
Chloride	1	mg/L	nd	nd	-	-
Chromium	0.0005	mg/L	nd	nd	0.0006	0.0006
Cobalt	0.0002	mg/L	nd	nd	nd	nd
Colour	5	TCU	nd	nd	-	-
Conductivity - @25øC	1	us/cm	1	3	-	-
Copper	0.0003	mg/L	nd	0.0049	0.0008	0.0013
Dissolved Inorganic Carbon(as C)	0.2	mg/L	nd	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	0.5	-	-	-
Hardness(as CaCO3)	0.1	mg/L	nd	nd	-	-
Ion Balance	0.01	%	100	53.2	-	-
Iron	0.02	mg/L	nd	0.03	0.05	0.06
Langelier Index at 20øC	na	na	NCALC	NCALC	-	-
Langelier Index at 4øC	na	na	NCALC	NCALC	-	-
Lead	0.0001	mg/L	nd	nd	0.0006	0.0007
Magnesium	0.1	mg/L	nd	nd	nd	nd
Manganese	0.0005	mg/L	nd	nd	nd	0.0009
Mercury (total)	0.0001	mg/L	-	nd	-	-
Mercury (dissolved)	0.0001	mg/L	nd	-	-	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	nd	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-
pH	0.1	Units	7.6	7.8	-	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	nd	-	-	-
Potassium	0.5	mg/L	nd	nd	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	nd	nd	-	-
Saturation pH at 20øC	na	units	NCALC	NCALC	-	-
Saturation pH at 4øC	na	units	NCALC	NCALC	-	-
Selenium	0.002	mg/L	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd
Sodium	0.1	mg/L	nd	nd	nd	nd
Strontium	0.005	mg/L	nd	nd	nd	nd
Sulphate	2	mg/L	nd	nd	-	-
Thallium	0.0001	mg/L	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	nd	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	nd	-	-
Total Suspended Solids	1	mg/L	nd	nd	-	-
Turbidity	0.1	NTU	0.4	0.2	-	-
Uranium	0.0001	mg/L	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd
Zinc	0.001	mg/L	nd	nd	0.003	0.006
Fluoride	0.02	mg/L	nd	nd	-	-

Table A2.3: Myra Falls Sediment QA/QC - Total Metals

Component	MDL	Units	MF3-S 97/09/07	MF3-S 97/09/07 Lab Rep	DQA (% diff) vs. R.	MF3-S 97/09/07 M. Spike	MF3-S 97/09/07 MS % Rec.	MN5-S 97/09/10	MN5-S 97/09/10 Lab Rep	DQA (% diff) vs. R.
Aluminum	1	mg/kg	27000	27000	**0.00**	NS	NS	14000	-	-
Antimony	0.2	"	0.3	0.2	**40.00**	55	110	1.8	-	-
Arsenic	0.5	"	9.6	8.8	**8.70**	480	96	59	-	-
Barium	0.5	"	110	100	**9.52**	600	99	140	-	-
Beryllium	0.2	"	0.3	0.3	**0.00**	450	89	0.3	-	-
Bismuth	0.5	"	<	<	-	48	96	3.4	-	-
Boron	2.5	"	5.1	<	-	410	81	<	-	-
Cadmium	0.05	"	2.3	2.3	**0.00**	54	100	13	-	-
Chromium	0.6	"	42	41	**2.41**	520	95	33	-	-
Cobalt	0.2	"	28	28	**0.00**	510	97	14	-	-
Copper	0.2	"	250	240	**4.08**	710	93	1000	-	-
Iron	20	"	41000	41000	**0.00**	NS	NS	38000	-	-
Lead	0.1	"	51	50	**1.98**	95	90	650	-	-
Manganese	1	"	1200	1200	**0.00**	NS	NS	1600	-	-
Molybdenum	0.2	"	1.7	1.6	**6.06**	55	110	36	-	-
Nickel	0.5	"	41	40	**2.47**	500	89	21	-	-
Selenium	1	"	2	1.4	**35.29**	470	94	2	-	-
Silver	0.05	"	0.48	0.47	**2.11**	NS	NS	15	-	-
Strontium	0.5	"	37	41	**10.26**	89	100	31	-	-
Thallium	0.2	"	<	<	-	50	100	0.2	-	-
Tin	0.2	"	1	1.1	**9.52**	56	110	0.6	-	-
Titanium	0.3	"	2700	2600	**3.77**	3200	110	340	-	-
Vanadium	1	"	160	160	**0.00**	640	97	54	-	-
Zinc	1	"	430	410	**4.76**	890	94	2200	-	-
										-
Calcium	20	mg/kg	23132.5	24445	**5.52**	-	-	6070	-	-
Magnesium	20	"	17427.5	18467.5	**5.79**	-	-	15487.5	-	-
										-
pH (20 DEG C)			6.07	-	-	-	-	6.23	6.28	**0.80**
Loss on Ignition	0.1	(%)	17	-	-	-	-	6.8	-	-
Coarse Gravel (>4.8mm)	0.1	%	<	-	-	-	-	<	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	1.6	-	-	-	-	0.2	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	1.8	-	-	-	-	0.4	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	4.5	-	-	-	-	4.4	-	-
Med. Sand (0.25-0.50mm)	0.1	"	3.9	-	-	-	-	4.1	-	-
Fine Sand (0.10-0.25mm)	0.1	"	4	-	-	-	-	5.5	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	23	-	-	-	-	12	-	-
Silt (0.002-0.050mm)	0.1	"	49	-	-	-	-	51	-	-
Clay (<0.002mm)	0.1	"	12	-	-	-	-	23	-	-
V. Fine Sand, Silt, Clay (<0.10mm) **										
Mercury	0.04	mg/kg	0.12	0.12	**0.00**	1.1	96	0.29	-	-
TOC (Solid)	0.1	(%)	5.5	-	-	-	-	2	-	-
Bulk Density		g/ml	0.34					0.46		
Moisture Content		%	71.5					64.3		
Munsell Number			5Y 2.5/2					5Y 4/3		
Munsell Colour			Black					Olive		

** Due to high moisture content, there was insufficient sample to conduct hydrometer test for fines, silt and clay

Table A2.3: Myra Falls Sediment QA/QC - Total Metals

Component	MDL	Units	MN9-S 97/09/11	MN9-S 97/09/11 Lab Rep	DQA (% diff) vs. R.	MN9-S 97/09/11 M. Spike	MN9-S 97/09/11 MS % Rec.	MR1-S 97/09/04	MR1-S 97/09/04 Lab Rep	DQA (% diff) vs. R.	MR1-S 97/09/04 M. Spike	MR1-S 97/09/04 MS % Rec.
Aluminum	1	mg/kg	22000	20000	**9.52**	NS	NS	20000	20000	**0.00**	NS	NS
Antimony	0.2	"	1.1	1.2	**8.70**	56	110	0.2	0.2	**0.00**	52	100
Arsenic	0.5	"	53	50	**5.83**	530	95	13	13	**0.00**	490	95
Barium	0.5	"	700	680	**2.90**	1200	96	78	79	**1.27**	550	94
Beryllium	0.2	"	0.4	0.4	**0.00**	460	92	0.3	0.3	**0.00**	49	97
Bismuth	0.5	"	2.9	3.1	**6.67**	54	100	<	<	-	49	97
Boron	2.5	"	<	<	-	410	81	<	<	-	400	79
Cadmium	0.05	"	9.7	10	**3.05**	63	110	0.35	0.4	**13.33**	50	100
Chromium	0.6	"	44	41	**7.06**	530	98	36	38	**5.41**	510	96
Cobalt	0.2	"	23	22	**4.44**	520	100	23	23	**0.00**	530	100
Copper	0.2	"	1200	1100	**8.70**	1700	99	76	76	**0.00**	550	96
Iron	20	"	43000	40000	**7.23**	NS	NS	33000	34000	**2.99**	NS	NS
Lead	0.1	"	700	660	**5.88**	1200	100	40	40	**0.00**	92	100
Manganese	1	"	2000	1900	**5.13**	2400	99	19000	20000	**5.13**	NS	NS
Molybdenum	0.2	"	20	21	**4.88**	77	110	1	0.9	**10.53**	55	110
Nickel	0.5	"	29	27	**7.14**	500	92	19	20	**5.13**	500	96
Selenium	1	"	2.2	1.7	**25.64**	460	92	2	2.1	**4.88**	460	92
Silver	0.05	"	8.9	9.6	**7.57**	NS	NS	0.25	0.25	**0.00**	NS	NS
Strontium	0.5	"	27	29	**7.14**	85	110	18	18	**0.00**	74	110
Thallium	0.2	"	<	<	-	53	110	<	<	-	50	100
Tin	0.2	"	0.6	0.7	**15.38**	56	110	1.1	1.1	**0.00**	54	110
Titanium	0.3	"	850	820	**3.59**	1300	95	720	700	**2.82**	1200	96
Vanadium	1	"	100	93	**7.25**	600	100	100	100	**0.00**	600	100
Zinc	1	"	2300	2100	**9.09**	2700	110	59	61	**3.33**	510	91
Calcium	20	mg/kg	9730	9522.5	**2.16**	-	-	10067.5	9802.5	**2.67**	-	-
Magnesium	20	"	17227.5	17132.5	**0.55**	-	-	6852.5	6827.5	**0.37**	-	-
pH (20 DEG C)			6.55	-	-	-	-	5.8	-	-	-	-
Loss on Ignition	0.1	(%)	12	-	-	-	-	17	16	-	-	-
Coarse Gravel (>4.8mm)	0.1	%	<	-	-	-	-	<	-	-	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	0.8	-	-	-	-	<	-	-	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.6	-	-	-	-	0.4	-	-	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	2.1	-	-	-	-	28	-	-	-	-
Med. Sand (0.25-0.50mm)	0.1	"	3.8	-	-	-	-	22	-	-	-	-
Fine Sand (0.10-0.25mm)	0.1	"	8.4	-	-	-	-	13	-	-	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	13	-	-	-	-			-		
Silt (0.002-0.050mm)	0.1	"	51	-	-	-	-			-		
Clay (<0.002mm)	0.1	"	20	-	-	-	-			-		
V. Fine Sand, Silt, Clay (<0.10mm) **								37	-		-	-
Mercury	0.04	mg/kg	0.3	0.3	**0.00**	1.3	97	0.3	-	-	-	-
TOC (Solid)	0.1	(%)	3.3	-	-	-	-	6.2	-	-	-	-
Bulk Density		g/ml	0.31					0.16				
Moisture Content		%	74.2					85.1				
Munsell Number			5Y 3/2					10YR 2/2				
Munsell Colour			Dark olive grey					ery dark brown				

** Due to high moisture content, there was insufficient sample to conduct hydrometer test for fines, silt and clay

Table A2.4: Myra Falls Sediment QA/QC - Partially Extracted Metals

Component	MDL	Units	MF3-S 97/09/07	MF3-S 97/09/07 Lab Rep	**DQA (% diff) vs. R.**	MF3-S 97/09/07 M. Spike	MF3-S 97/09/07 MS % Rec.	MN9-S 97/09/11	MN9-S 97/09/11 Lab Rep	**DQA (% diff) vs. R.**
Aluminum (ext.)	1	mg/kg	1600	1500	**6.45**	NS	NS	2100	2200	**4.65**
Antimony (ext.)	0.2	"	<	<	-	260	100	<	<	-
Arsenic (ext.)	0.5	"	<	<	-	25	99	<	<	-
Barium (ext.)	0.5	"	31	31	**0.00**	270	96	160	170	**6.06**
Beryllium (ext.)	0.2	"	<	<	-	240	96	0.2	0.2	**0.00**
Bismuth (ext.)	0.5	"	<	<	-	26	100	<	<	-
Boron (ext.)	2.5	"	<	<	-	210	85	<	<	-
Cadmium (ext.)	0.05	"	0.56	0.51	**9.35**	25	97	2.3	2.2	**4.44**
Chromium (ext.)	0.6	"	4.5	4.4	**2.25**	260	100	4.9	5.3	**7.84**
Cobalt (ext.)	0.2	"	4.1	4.1	**0.00**	270	110	4.4	4.6	**4.44**
Copper (ext.)	0.2	"	2.4	2.4	**0.00**	260	100	6.3	6	**4.88**
Iron (ext.)	20	"	4200	4100	**2.41**	NS	NS	5600	5800	**3.51**
Lead (ext.)	0.1	"	5.4	5.4	**0.00**	31	100	220	210	**4.65**
Manganese (ext.)	1	"	460	460	**0.00**	710	98	820	880	**7.06**
Molybdenum (ext.)	0.2	"	<	<	-	25	100	<	<	-
Nickel (ext.)	0.5	"	1.9	1.9	**0.00**	260	100	2.2	2.4	**8.70**
Selenium (ext.)	1	"	<	<	-	240	98	<	<	-
Silver (ext.)	0.05	"	<	<	-	NS	NS	<	<	-
Strontium (ext.)	0.5	"	4.9	4.9	**0.00**	30	99	3.2	3.1	**3.17**
Thallium (ext.)	0.2	"	<	<	-	26	100	<	<	-
Tin (ext.)	0.2	"	<	<	-	24	98	<0.5	<0.5	-
Titanium (ext.)	0.3	"	0.9	0.9	**0.00**	250	100	1	1	**0.00**
Vanadium (ext.)	1	"	18	18	**0.00**	280	110	11	11	**0.00**
Zinc (ext.)	1	"	140	140	**0.00**	370	94	790	830	**4.94**
Calcium	20	mg/kg	3716	3710	**0.16**	-	-	2128	2130	**0.09**
Magnesium	20	"	528	512	**3.08**	-	-	348	343	**1.62**

Table A2.4: Myra Falls Sediment QA/QC - Partially Extracted Metals

Component	MDL	Units	MN9-S 97/09/11 M. Spike	MN9-S 97/09/11 MS % Rec.	MR1-S 97/09/04	MR1-S 97/09/04 Lab Rep	**DQA (% diff) vs. R.**	MR1-S 97/09/04 M. Spike	MR1-S 97/09/04 MS % Rec.
Aluminum (ext.)	1	mg/kg	NS	NS	2900	2900	**0.00**	NS	NS
Antimony (ext.)	0.2	"	250	100	0.2	<	-	260	100
Arsenic (ext.)	0.5	"	25	99	<	<	-	NS	NS
Barium (ext.)	0.5	"	400	94	22	22	**0.00**	260	100
Beryllium (ext.)	0.2	"	250	98	<	<	-	240	95
Bismuth (ext.)	0.5	"	26	100	<	<	-	NS	NS
Boron (ext.)	2.5	"	210	84	<	<	-	210	83
Cadmium (ext.)	0.05	"	26	98	0.14	0.14	**0.00**	NS	NS
Chromium (ext.)	0.6	"	260	100	7.2	7.3	**1.38**	260	100
Cobalt (ext.)	0.2	"	270	110	5.9	6	**1.68**	270	110
Copper (ext.)	0.2	"	260	100	3.8	3.7	**2.67**	260	100
Iron (ext.)	20	"	NS	NS	4800	4700	**2.11**	NS	NS
Lead (ext.)	0.1	"	240	71	6	6.1	**1.65**	25	96
Manganese (ext.)	1	"	1000	76	8500	8400	**1.18**	NS	NS
Molybdenum (ext.)	0.2	"	25	100	<	<	-	NS	NS
Nickel (ext.)	0.5	"	250	100	1.6	1.6	**0.00**	250	100
Selenium (ext.)	1	"	240	97	<	<	-	240	94
Silver (ext.)	0.05	"	NS	NS	<	<	-	NS	NS
Strontium (ext.)	0.5	"	28	100	4	4	**0.00**	NS	NS
Thallium (ext.)	0.2	"	250	100	<	<	-	NS	NS
Tin (ext.)	0.2	"	24	99	<	<	-	NS	NS
Titanium (ext.)	0.3	"	250	100	1.3	1.2	**8.00**	250	100
Vanadium (ext.)	1	"	280	110	14	14	**0.00**	280	110
Zinc (ext.)	1	"	1000	85	11	11	**0.00**	240	92
Calcium	20	mg/kg	-	-	2288	2296	**0.35**	-	-
Magnesium	20	"	-	-	216	212	**2.06**	-	-

Table A2.5: Myra Falls Sediment QA/QC - SEM Metals

Component	MDL	MF2-S umol/g	MF2-S umol/g Lab Rep	**DQA (% diff) vs. R.**	MF3-S umol/g	MF3-S umol/g Lab Rep	**DQA (% diff) vs. R.**	MN9-S umol/g	MN9-S umol/g Lab Rep	**DQA (% diff) vs. R.**
Aluminum	2	1195.6	1195.6	**0.00**	1090.1	937.3	**15.08**	303.6	283.3	**6.90**
Barium	0.1	3.0	2.6	**14.63**	1.5	1.4	**8.04**	10.7	11.1	**3.64**
Beryllium	0.1	<	<	-	<	<	-	<	<	-
Boron	1	2.1	1.9	**8.70**	3.2	2.3	**29.73**	0.6	<	-
Cadmium	0.05	0.1	0.1	**21.05**	0.0	0.0	**2.33**	0.0	0.0	**0.00**
Calcium	7	383.5	359.8	**6.37**	322.9	315.5	**2.33**	61.3	74.9	**20.00**
Chromium	0.1	0.4	0.4	**0.00**	0.3	0.3	**16.60**	0.1	0.1	**7.41**
Cobalt	0.2	0.8	0.7	**16.67**	0.5	0.4	**15.65**	0.2	0.2	**5.13**
Copper	0.1	9.9	10.2	**2.99**	6.3	5.8	**8.38**	12.0	12.9	**6.90**
Iron	0.2	1088.2	986.2	**9.84**	695.8	556.2	**22.30**	313.1	274.0	**13.33**
Lead	0.4	0.7	0.8	**15.19**	0.4	0.5	**3.97**	2.6	2.9	**9.52**
Magnesium	3	168.8	119.6	**34.15**	218.0	140.6	**43.19**	62.7	30.4	**69.57**
Manganese	0.1	314.5	207.4	**41.06**	40.7	37.7	**7.73**	26.9	32.8	**20.00**
Molybdenum	0.1	<	<	-	<	<	-	<	<	-
Nickel	0.2	0.5	<	-	0.5	0.4	**15.65**	0.2	0.1	**51.85**
Potassium	10	<	<	-	<	<	-	<	<	-
Silver	0.1	<	<	-	<	<	-	<	<	-
Sodium	6	21.5	17.3	-	15.9	11.0	**36.22**	3.6	2.6	**30.77**
Strontium	0.1	0.5	0.5	**4.44**	0.6	0.6	**9.22**	0.3	0.3	**2.30**
Sulphur	3	7.7	7.1	-	3.7	4.3	**15.87**	9.0	8.0	**12.00**
Thallium	0.5	<	<	-	<	<	-	<	<	-
Tin	0.5	<	<	-	<	<	-	<	<	-
Titanium	0.3	14.7	15.8	**7.79**	15.0	13.0	**14.49**	2.3	2.1	**10.53**
Vanadium	0.1	2.8	2.8	**1.34**	3.0	2.7	**10.32**	0.5	0.5	**8.33**
Zinc	0.1	25.0	26.7	**6.74**	17.8	13.7	**26.02**	27.6	30.9	**11.43**
Zirconium	0.5	<	<	-	<	<	-	<	<	-
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		36.0	37.7	**4.64**	25.1	20.4	**20.50**	42.4	46.8	**9.85**
AV Sulphide	0.1	1.0	1.9	**62.07**	<0.1	<0.1	-	13.2	14.0	**5.88**
SEM/AVS Ratio		36.0	19.8	**57.84**	>25	>20	-	3.2	3.3	**3.98**

Table A2.6: Myra Falls - Comparison of Aqua Regia Metals to Total Metals

Component	MDL	Units	AR MF4-S	AR MF4-S Field Dup	**DQA (% diff) vs. FD**	Total MF4-S	AR MN4-S	Total MN4-S
Aluminum	30	mg/kg	44000	43000	**2.30**	34000	25000	22000
Barium	0.2	"	99	98	**1.02**	97	1500	1200
Beryllium	0.1	"	0.5	0.4	**22.22**	0.4	0.3	0.4
Boron	10	"	<	<	-	<	<	<
Cadmium	0.2	"	1.2	0.9	**28.57**	0.86	12	12
Calcium	20	"	18000	17000	**5.71**	-	5500	-
Chromium	5	"	46	44	**4.44**	47	40	47
Cobalt	5	"	40	39	**2.53**	33	22	22
Copper	5	"	200	200	**0.00**	180	1100	1100
Iron	5	"	59000	59000	**0.00**	49000	55000	50000
Lead	10	"	13	15	**14.29**	14	690	760
Magnesium	40	"	15000	15000	**0.00**	-	14000	-
Manganese	5	"	1500	1500	**0.00**	1400	1600	1600
Molybdenum	1	"	2	2	**0.00**	1.4	22	23
Nickel	5	"	51	51	**0.00**	50	30	30
Phosphorus	50	"	890	870	**2.27**	-	710	-
Potassium	100	"	600	530	**12.39**	-	960	-
Silicon	10	"	3300	3000	**9.52**	-	1500	-
Silver	0.5	"	<	<	-	0.3	9.3	11
Sodium	50	"	710	670	**5.80**	-	150	-
Strontium	0.1	"	44	43	**2.30**	46	42	37
Sulphur	10	"	490	480	**2.06**	-	11000	-
Thallium	20	"	<	<	-	<	<	0.2
Tin	5	"	<	<	-	0.9	<	0.9
Titanium	5	"	5100	4800	**6.06**	4600	860	840
Vanadium	10	"	200	190	**5.13**	200	84	93
Zinc	5	"	230	230	**0.00**	220	3300	3000
Zirconium	5	"	16	14	**13.33**	-	<	-

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MR1-S SEM	MR1-S Tot	MR1-S Lab Rep T	MR2-S SEM	MR2-S Tot	MR3-S SEM	MR3-S Tot	MR4-S SEM	MR4-S Tot
Aluminum	2	mg/kg	26597.3	20000	20000	31219.3	18000	18984.1	19000	25170.8	18000
Barium	0.1	mg/kg	150.7	78	79	168.6	90	89.5	73	232.3	130
Beryllium	0.1	mg/kg	<	0.3	0.3	<	0.3	<	0.3	<	0.3
Boron	1	mg/kg	24.8	<	<	22.9	<	<	<	31.0	<
Cadmium	0.05	mg/kg	<	0.35	0.4	<	0.35	<	0.34	<	0.39
Calcium	7	mg/kg	5851.1	-	-	7076.0		4339.0		7357.2	
Chromium	0.1	mg/kg	11.9	36	38	14.4	35	10.6	36	<	32
Cobalt	0.2	mg/kg	31.9	23	23	29.1	24	17.6	22	27.1	25
Copper	0.1	mg/kg	92.2	76	76	110.3	72	66.4	75	98.8	76
Iron	0.2	mg/kg	118894.4	33000	34000	58321.7	44000	25784.4	35000	56194.4	53000
Lead	0.4	mg/kg	69.2	40	40	79.2	42	58.4	44	75.6	49
Magnesium	3	mg/kg	1453.5	-	-	2249.8		1343.6		1552.3	
Manganese	0.1	mg/kg	35485.5	19000	20000	41652.1	23000	17639.3	15000	52311.1	28000
Molybdenum	0.1	mg/kg	<	1	0.9	<	1	<	0.9	<	1.2
Nickel	0.2	mg/kg	17.7	19	20	<	19	16.3	20	<	20
Potassium	10	mg/kg	<	-	-	<		<		<	
Silver	0.1	mg/kg	<	0.25	0.25	<	0.24	<	0.27	<	0.29
Sodium	6	mg/kg	<	-	-	249.6		203.3		406.4	
Strontium	0.1	mg/kg	28.4	18	18	33.3	20	20.3	20	40.7	28
Sulphur	3	mg/kg	336.5	-	-	374.1		230.2		638.1	
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	1.1	1.1	<	3	<	1	<	0.8
Titanium	0.3	mg/kg	372.3	720	700	457.9	710	298.3	740	367.9	1200
Vanadium	0.1	mg/kg	76.3	100	100	95.8	96	63.8	97	60.1	95
Zinc	0.1	mg/kg	69.1	59	61	97.8	59	52.9	61	73.5	63

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MR5-S SEM	MR5-S Tot	MR6-S SEM	MR6-S Tot	MR7-S SEM	MR7-S Tot	MF1-S SEM	MF1-S Tot
Aluminum	2	mg/kg	36542.9	18000	13094.0	19000	28428.0	19000	40779.0	30000
Barium	0.1	mg/kg	243.6	90	130.9	91	284.2	140	291.2	140
Beryllium	0.1	mg/kg	<	0.3	<	0.2	<	0.3	<	0.4
Boron	1	mg/kg	36.5	<	<	<	20.3	<	27.2	<
Cadmium	0.05	mg/kg	<	0.4	<	0.39	<	0.42	<	1.1
Calcium	7	mg/kg	9987.8		4037.1		8324.9		16310.7	
Chromium	0.1	mg/kg	16.3	32	4.6	34	<	35	31.1	53
Cobalt	0.2	mg/kg	51.2	24	21.8	25	34.5	31	44.7	36
Copper	0.1	mg/kg	141.3	75	54.6	79	123.9	87	369.0	190
Iron	0.2	mg/kg	107276.6	39000	48049.2	41000	83318.9	63000	68018.4	57000
Lead	0.4	mg/kg	121.9	53	42.6	53	89.4	49	<	18
Magnesium	3	mg/kg	2852.9		1081.2		2560.8		6297.2	
Manganese	0.1	mg/kg	65819.0	26000	26204.7	26000	89401.9	36000	6023.6	2500
Molybdenum	0.1	mg/kg	<	1.3	<	1.2	<	1.6	<	1.8
Nickel	0.2	mg/kg	26.8	20	<	21	24.4	26	36.9	47
Potassium	10	mg/kg	<		<		<		<	
Silver	0.1	mg/kg	<	0.29	<	0.29	<	0.25	<	0.34
Sodium	6	mg/kg	487.0		152.7		405.9		562.9	
Strontium	0.1	mg/kg	53.6	27	20.7	26	50.8	27	50.5	28
Sulphur	3	mg/kg	462.3		185.3		446.1		213.3	
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	1	<	1.1	<	1.8	<	0.8
Titanium	0.3	mg/kg	609.0	790	229.1	810	487.3	980	932.0	3000
Vanadium	0.1	mg/kg	107.3	92	38.2	98	56.9	100	173.0	180
Zinc	0.1	mg/kg	102.3	58	41.4	61	91.3	69	562.9	240

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MF2-S SEM	MF2-S Lab Rep - S	MF2-S Tot	MF3-S SEM	MF3-S Lab Rep - S	MF3-S Tot	MF3-S Lab Rep -T	MF4-S SEM	MF4-S Tot
Aluminum	2	mg/kg	32259.9	32259.9	28000	29413.4	25288.8	27000	27000	50142.1	34000
Barium	0.1	mg/kg	417.4	360.5	97	211.7	195.4	110	100	260.0	97
Beryllium	0.1	mg/kg	<	<	0.4	<	<	0.3	0.3	<	0.4
Boron	1	mg/kg	22.8	20.9	<	34.1	25.3	5.1	<	22.3	<
Cadmium	0.05	mg/kg	6.5	8.0	3.1	3.6	3.6	2.3	2.3	<	0.86
Calcium	7	mg/kg	15370.0	14421.3		12941.2	12643.7			22284.1	
Chromium	0.1	mg/kg	22.8	22.8	49	17.6	14.9	42	41	29.7	47
Cobalt	0.2	mg/kg	49.3	41.7	35	28.2	24.1	28	28	39.0	33
Copper	0.1	mg/kg	626.2	645.2	310	400.0	367.9	250	240	408.6	180
Iron	0.2	mg/kg	60772.2	55074.8	53000	38856.2	31060.6	41000	41000	44605.8	49000
Lead	0.4	mg/kg	138.7	161.4	70	90.7	94.3	51	50	<	14
Magnesium	3	mg/kg	4102.6	2906.0		5299.1	3417.0			6022.4	
Manganese	0.1	mg/kg	17279.5	11393.1	5000	2236.8	2070.4	1200	1200	3159.1	1400
Molybdenum	0.1	mg/kg	<	<	2.6	<	<	1.7	1.6	<	1.4
Nickel	0.2	mg/kg	26.6	<	43	28.2	24.1	41	40	37.1	50
Potassium	10	mg/kg	<	<		<	<			<	
Silver	0.1	mg/kg	<	<	0.64	<	<	0.48	0.47	<	0.3
Sodium	6	mg/kg	493.1	398.3		364.5	252.8			575.4	
Strontium	0.1	mg/kg	43.7	41.8	30	53.0	48.3	37	41	72.4	46
Sulphur	3	mg/kg	246.4	227.4		117.5	137.8			241.1	
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	<	0.7	<	<	1	1.1	<	0.9
Titanium	0.3	mg/kg	702.1	759.0	2500	717.6	620.7	2700	2600	1244.2	4600
Vanadium	0.1	mg/kg	140.5	142.4	160	153.1	138.0	160	160	204.4	200
Zinc	0.1	mg/kg	1631.4	1745.2	630	1164.3	896.3	430	410	501.2	220

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MF5-S SEM	MF5-S Tot	MF6-S SEM	MF6-S Tot	MF7-S SEM	MF7-S Tot	MN4-S SEM	MN4-S Tot
Aluminum	2	mg/kg	40759.2	24000	50142.1	25000	29603.9	25000	11270.1	22000
Barium	0.1	mg/kg	218.3	86	260.0	170	259.0	170	1789.7	1200
Beryllium	0.1	mg/kg	<	0.3	<	0.3	<	0.3	<	0.4
Boron	1	mg/kg	18.9	<	22.3	<	<	<	7.3	<
Cadmium	0.05	mg/kg	<	1.1	<	2.1	<	1.4	8.6	12
Calcium	7	mg/kg	14556.0		22284.1		14061.1		4110.0	
Chromium	0.1	mg/kg	30.6	39	29.7	44	22.2	47	11.9	47
Cobalt	0.2	mg/kg	42.2	26	39.0	32	29.6	28	13.9	22
Copper	0.1	mg/kg	276.6	140	408.6	220	296.1	160	1060.8	1100
Iron	0.2	mg/kg	46618.6	41000	44605.8	55000	27775.5	41000	27202.2	50000
Lead	0.4	mg/kg	<	14	<	50	40.7	26	929.0	760
Magnesium	3	mg/kg	5769.7		6022.4		4166.8		2090.1	
Manganese	0.1	mg/kg	3641.5	1600	3159.1	7800	3147.4	1600	1592.1	1600
Molybdenum	0.1	mg/kg	<	1.9	<	2.6	<	1.6	<	23
Nickel	0.2	mg/kg	27.7	37	37.1	40	27.8	40	9.3	30
Potassium	10	mg/kg	<		<		<		<	
Silver	0.1	mg/kg	<	0.33	<	0.54	<	0.42	<	11
Sodium	6	mg/kg	494.7		575.4		499.3		99.4	
Strontium	0.1	mg/kg	49.5	41	72.4	34	42.6	30	33.8	37
Sulphur	3	mg/kg	139.6		241.1		184.8		437.0	
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	0.2
Tin	0.5	mg/kg	<	0.7	<	0.6	<	1	<	0.9
Titanium	0.3	mg/kg	960.7	2600	1244.2	2700	573.5	2300	106.1	840
Vanadium	0.1	mg/kg	160.2	140	204.4	160	144.4	150	33.8	93
Zinc	0.1	mg/kg	378.3	170	501.2	390	480.9	240	2783.4	3000

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MN5-S SEM	MN5-S Tot	MN6-S SEM	MN6-S Tot	MN7-S SEM	MN7-S Tot	MN8-S SEM	MN8-S Tot
Aluminum	2	mg/kg	13544.8	14000	40705.4	23000	11642.1	21000	8649.9	23000
Barium	0.1	mg/kg	2708.6	140	5365.0	1200	2172.9	1100	1796.3	1400
Beryllium	0.1	mg/kg	<	0.3	<	0.5	<	0.4	<	0.5
Boron	1	mg/kg	<	<	29.6	<	9.3	<	8.0	3.1
Cadmium	0.05	mg/kg	9.9	13	18.5	7.8	8.5	10	7.3	9.5
Calcium	7	mg/kg	4605.0		10360.8		3492.4		2661.3	
Chromium	0.1	mg/kg	14.4	33	40.7	48	10.9	46	7.3	49
Cobalt	0.2	mg/kg	18.1	14	55.5	25	32.6	23	12.0	26
Copper	0.1	mg/kg	1896.3	1000	3885.7	1300	1707.6	1400	1131.2	1500
Iron	0.2	mg/kg	45184.8	38000	109250.1	52000	39614.2	50000	27301.8	58000
Lead	0.4	mg/kg	1717.2	650	2592.7	760	1243.0	890	799.2	920
Magnesium	3	mg/kg	1952.2		6833.5		978.8		719.2	
Manganese	0.1	mg/kg	3885.3	1600	9812.5	3000	10872.9	7900	8655.4	10000
Molybdenum	0.1	mg/kg	<	36	<	23	<	31	<	26
Nickel	0.2	mg/kg	13.5	21	44.4	33	12.4	29	<	32
Potassium	10	mg/kg	<		<		<		<	
Silver	0.1	mg/kg	<	15	<	11	<	12	<	11
Sodium	6	mg/kg	99.3		369.9		<		73.2	
Strontium	0.1	mg/kg	48.8	31	96.2	43	34.9	41	28.0	40
Sulphur	3	mg/kg	595.2		1201.1		488.3		405.3	
Thallium	0.5	mg/kg	<	0.2	<	<	<	<	<	<
Tin	0.5	mg/kg	<	0.6	<	0.8	<	0.7	<	0.6
Titanium	0.3	mg/kg	108.4	340	425.5	940	124.2	730	93.1	830
Vanadium	0.1	mg/kg	34.3	54	122.2	100	31.8	88	24.0	100
Zinc	0.1	mg/kg	4423.0	2200	7213.3	1900	3491.4	2400	2394.5	2600

Table A2.7: Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	MN9-S SEM	MN9-S Lab Rep - S	MN9-S Tot	MN9-S Lab Rep - T	MN10-S SEM	MN10-S Tot
Aluminum	2	mg/kg	8190.5	7644.4	22000	20000	7457.5	20000
Barium	0.1	mg/kg	1474.1	1528.7	700	680	1292.5	1400
Beryllium	0.1	mg/kg	<	<	0.4	0.4	<	0.4
Boron	1	mg/kg	6.6	<	<	<	6.0	<
Cadmium	0.05	mg/kg	5.3	5.3	9.7	10	6.0	9.9
Calcium	7	mg/kg	2457.0	3003.0			2634.8	
Chromium	0.1	mg/kg	7.6	7.1	44	41	6.0	39
Cobalt	0.2	mg/kg	10.9	10.4	23	22	11.9	25
Copper	0.1	mg/kg	764.5	819.1	1200	1100	696.1	800
Iron	0.2	mg/kg	17486.7	15300.9	43000	40000	20897.5	47000
Lead	0.4	mg/kg	546.5	601.2	700	660	393.1	430
Magnesium	3	mg/kg	1524.8	737.8			671.8	
Manganese	0.1	mg/kg	1475.2	1803.0	2000	1900	7462.3	9100
Molybdenum	0.1	mg/kg	<	<	20	21	<	17
Nickel	0.2	mg/kg	9.3	5.5	29	27	5.0	29
Potassium	10	mg/kg	<	<			<	
Silver	0.1	mg/kg	<	<	8.9	9.6	<	7
Sodium	6	mg/kg	81.9	60.0			84.5	
Strontium	0.1	mg/kg	23.5	24.0	27	29	20.4	44
Sulphur	3	mg/kg	289.0	256.3			263.2	
Thallium	0.5	mg/kg	<	<	<	<	<	<
Tin	0.5	mg/kg	<	<	0.6	0.7	<	0.9
Titanium	0.3	mg/kg	109.2	98.3	850	820	104.4	1100
Vanadium	0.1	mg/kg	27.3	25.1	100	93	25.9	100
Zinc	0.1	mg/kg	1801.3	2019.6	2300	2100	1540.7	1600

Table A2.8: Myra Falls Water Toxicity QA/QC

Organism	MSD (%)	Control Mortality (%)	Control CV (%)	Reference toxicant CV[3] (%)	Reference toxicant Endpoint[3]	Warning Limits (Mean ± 2 std.dev.)	Control Limits (Mean ± 3 std.dev.)
Ceriodaphnia dubia							
M-E-1	29	10	26	13	1700	1170 - 1980	963 - 2180
M-E-2	-[1]	10	33	14	1210	1120 - 1960	906 - 2170
M-E-3	29	0	28	14	1210	1120 - 1960	906 - 2170
M-E-4	-	0	42	15	1110	1040 - 1960	817 - 2190
Fathead Minnow							
M-E-1	27	10	7.6	20	1610	672 - 1600	440 - 1830
M-E-2	-	10	5.2	18	1100	705 - 1490	510 - 1680
M-E-3	16	0	4.7	18	996	698 - 1480	510 - 1680
M-E-4	22	17	3.7	19	923	681 - 1480	481 - 1680
Selenastrum capricornutum							
M-E-1	18	na[2]	7.0	32[4]	21.2	8.6 - 39.2	1.0 - 46.8
M-E-2	11	na	9.0	46	53.8	2.7 - 58.1	-11.2 - 72
M-E-3	23	na	20	42	35.4	4.6 - 55.4	-8.0 - 68.1
M-E-4	32	na	21	40	31.7	6.2 - 52.9	-5.5 - 64.6

[1] - = MSD (minimum significant difference) value not available from the statistical methods used.

[2] na = Not applicable for the corresponding test.

[3] Based on IC50 for *Ceriodaphnia dubia* and Fathead Minnow and IC25 for *Selenastrum capricornutum*.

[4] The high CV values associated with the algae test are largely the result of the recent adaptation of the test by Beak. As a result, the control chart for this test is not as established as those for other reference toxicant tests. It is expected that after more points are added to the control chart, the CV will be reduced to a level consistent with the Ceriodaphnia and fathead minnow reference toxicant tests (approximately 20%). Higher variability with the Selenastrum test may also be attributed to the reference toxicant, zinc sulphate, which does not provide as consistent results as do salts, such as sodium chloride and potassium chloride. Variability associated with the reference toxicant test is considered to be a function of issues specific to the reference testing, such as the toxicant, and is not representative of the effluent test results. During the CANMET project, three Selenastrum tests were conducted in parallel, one for each mine site. Results of each pair of tests were within each other's confidence limits, even though different dilution waters were used. The average difference between IC50s for each pair was 16%, indicating a high degree of precision.

Table A2.9: Myra Falls Sediment Toxicity QA/QC

Organism	Control Mortality (%)	Control CV (%)	Re-test (survival) CV (%)	Re-test (growth) CV (%)
Chironomus riparius	6 - 14	6 - 11	12 - 64	18 - 49
Hyalella azteca	2 - 20	0 - 11	13 - 91	11 - 34

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

Zenon Environmental Inc.

ZENON ENVIRONMENTAL LABORATORIES INC. – BURLINGTON

5555 North Service Road, Burlington, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 197

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1998-03-06

President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

Beak Consultants Ltd.
ECOTOXICITY LABORATORY

14 Abacus Road, Brampton, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

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pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 168

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1999-03-06

Richard Lafontaine

President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

CAEAL 1996 ACLAE

CAEAL 1997 ACLAE

Beak Consultants Ltd.
ECOTOXICOLOGY LABORATORY
455 Boul. Fenelon, Suite 104, Dorval, Québec

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 227

Accreditation Date
Date d'accréditation: 1996-02-15

Issued on
Émis ce : 1996-02-15

Expiry date
Date d'expiration : 2000-02-15

President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et les *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

ENVIRONNEMENT
ET FAUNE
QUÉBEC

N° 108

CERTIFICAT D'ACCRÉDITATION
DE LABORATOIRE D'ANALYSE ENVIRONNEMENTALE

Champ d'accréditation : **Toxicologie de l'eau**

Détenteur : **LES CONSULTANTS BEAK LTÉE**

Adresse : **455, boulevard Fénelon, bureau 104**
Dorval (Québec) H9S 5T8

N° de laboratoire : **428**

Service à la clientèle externe Oui [X] **Non** [ ]

Selon les dispositions de l'article 118.6 de la Loi sur la qualité de l'environnement (L.R.Q., chap. Q-2) et conformément aux normes et exigences d'accréditation incluant celles du Guide ISO/CEI 25, le détenteur de ce certificat est habilité à réaliser les analyses déterminées dans les domaines ci-dessous :

Domaine	Date d'entrée en vigueur	Date d'échéance
191 - - - - - - -	1997-07-02	1998-07-01

Le présent certificat, valide pour la période indiquée, est soumis aux règles et procédures établies et demeure la propriété du ministère de l'Environnement et de la Faune.

Québec, le 7 août 19 97

Le ministre de l'Environnement et de la Faune

Québec

APPENDIX 3

Station Coordinates and Habitat Information

TABLE A3.1: LOCATIONS AND DESCRIPTIONS OF SURVEY LOCATIONS IN MYRA CREEK, SEPTEMBER 1997

Station	Date/ Time	Location	General Habitat Description
MCR1	04/09/97 11:42	20 m upstream of Arnica Creek mouth	• 5 grabs collected for benthos along right upstream bank • substrate gravel bar • riparian vegetation, shrubs and deciduous trees ˜20% cover • no macrophytes, no algae observed
MCR2	04/09/97 12:31	49.3 m upstream of Station MCR1	• downstream end of unvegetated bar just at confluence with creek on right upstream bank - no flow coming from creek - dry • flow = 0.05 m/s to 0.11 m/s • riparian vegetation: cedar, hemlock, deciduous trees (alder), shrubs • ˜ 10% cover • wetted width ˜5 m (right upstream bank of unvegetated bar • some periphyton on rocks <5% • substrate: 60% cobble, 35% gravel, 5% sand
MCR3	04/09/97 1:10 p.m.	49.5 m upstream of Station MCR1	• substrate: 60% cobble, 35% gravel, 5% sand • wetted width ˜ 4 m (upstream side of unvegetated bar) • riparian vegetation: deciduous shrubs, log jam <5%, 0% cover • average depth: 18 cm
MCR4	04/09/97 2:02 p.m.	55.3 m upstream of Station MCR1 (RUB)	• average depth: 17 cm • no overhanging vegetation • substrate: 60% cobble, 30% gravel, 10% sand • wetted width: ˜4 m • sparse periphyton cover on rocks <5% (fuzzy, moss-like appearance)
MCR5	04/09/97 2:20 p.m.	55.3 upstream of Station MCR1 (RUB)	• average depth: 20 cm • substrate: 80% cobble, 20% gravel • wetted width: ˜ 17 m • sparse periphyton cover on rocks <5%
MCR6	04/09/97 2:50 p.m.	60 m upstream of Station MCR1	• average depth: 50 cm • substrate type: 90% gravel, 10% cobble • riparian vegetation, sparse conifers, shrubs, 0% cover • wetted width: 12 m • sparse periphyton cover <5%, moss-like appearance
MCR7	04/09/97 3:25 p.m.	˜70 m upstream of Station MCR1	• average depth: 50 cm • substrate type: 40% cobble, 55% gravel, 5% sand • riparian vegetation, conifers and shrubs on LUB - 5% cover • deciduous and shrubs on RUB <1% (gravel bar between water and end of vegetation) • wetted width: ˜15 m
MCR8	04/09/97 3:46 p.m.	7.7 m upstream of Station MCR1	• average depth: 40 cm • substrate type: cobble 5%, gravel 90%, sand 5% • riparian vegetation - similar to Station 7 (no cover) • upstream tip of unvegetated bar • wetted width: ˜20 m

TABLE A3.1: LOCATIONS AND DESCRIPTIONS OF SURVEY LOCATIONS IN MYRA CREEK, SEPTEMBER 1997 (cont'd)

Station	Date/ Time	Location	General Habitat Description
MCR9	04/09/97 4:13 p.m.	~78 m upstream of Station MCR1	• average depth: 40 cm • substrate type: 90% gravel, 10% sand • riparian vegetation: shrubs, <5% cover, undercut banks, conifers/deciduous mix • wetted width: ~20 m • sparse covering of periphyton on rocks • fish seen at this station
MCR10	04/09/97 4:50 p.m.	~85 m upstream of Station MCR1	• average depth: 55 cm • substrate type: 50% cobble, 50% gravel • riparian vegetation: RIB deciduous and shrubs <5% cover, LUB conifers/shrubs <10% cover • located at very upstream end of unvegetated bar on RUB • upstream of Station 10, substrate becomes bedrock again, deeper water and faster flows due to increased gradient, i.e., not good for benthic sampling • wetted width: ~17 m
MCE1	05/09/97 11:49 a.m.	tail end of widening in creek adjacent to Western Mine Road	• average depth: 19 cm • substrate type: 70% cobble, 30% pebble • no overhanging vegetation • wetted width: 20 m • sparse periphyton less than 5%
MCE2	05/09/97 12:10 p.m.	approximately 20 m upstream of Station MCE1	• average depth: 23 cm • substrate type: 70% cobble, 30% pebble • no overhanging vegetation • wetted width: ~20 m • ~5% periphyton
MCE3	05/09/97 12:27 p.m.	approximately 7 m upstream of Station MCE2, on opposite bank (away from gravel bar)	• average depth: 33 cm • overhanging vegetation, 10% deciduous • substrate: 80% cobble, 5% pebble, 5% gravel • wetted width: ~20 m • <5% periphyton
MCE4	05/09/97 12:47 p.m.	located 10 m upstream of Station MCE3 on other side of bank (closest to vegetated bar)	• average depth: 31 cm • wetted width: ~15 m • substrate type: 20% cobble, 60% pebble, 10% gravel, 10% sand • 0% overhanging vegetation • <5% periphyton
MCE5	05/09/97 1:15 p.m.	located 30 m upstream of Station 4, creek turns left around gravel bar	• average depth: 25 cm • wetted width: ~12 m • substrate type: 60% cobble, 30% pebble, 10% gravel • 0% overhanging vegetation • <5% periphyton

TABLE A3.1: LOCATIONS AND DESCRIPTIONS OF SURVEY LOCATIONS IN MYRA CREEK, SEPTEMBER 1997 (cont'd)

Station	Date/ Time	Location	General Habitat Description
MCE6	05/09/97 2:22 p.m.		• average depth: 27 cm • substrate type: 90% gravel, 10% sand • riparian vegetation: shrubs <5% cover • wetted width: ~7 m • vegetation growing on gravel bar • no periphyton
MCE7	05/09/97 2:48 p.m.	upstream of gravel bar (RUB) just before split in channel to go around bar, just before log jam	• average depth: 25 cm • riparian vegetation: shrubs, no cover • substrate type: 5% cobble, 90% gravel, 5% sand • no periphyton • wetted width: ~35 m
MCE8	05/09/97 3:00 p.m.	located just upstream of unvegetated bar on UIB	• average depth: 35 cm • riparian vegetation: LUB shrubs, undercut banks, <5% cover • substrate type: 90% gravel, 10% sand • wetted width: ~35 m • no periphyton
MCE9	05/09/97 3:25 p.m.	50 m upstream of Stations MCE7 and MCE8 mid-channel	• average depth: 30 cm • riparian vegetation: shrubs, 5% cover • substrate type: 20% cobble, 75% gravel, 5% sand • wetted width: ~30 m
MCE10	05/09/97 3:55 p.m.	upstream end of unvegetated bar ~100 m upstream of Station MCE9 (site sampled in June 1997 reconnaissance)	• average depth: 35 cm • riparian vegetation: RUB deciduous and conifer trees dominate, shrubs sparse • ~10% cover • substrate type: 90% gravel, 10% sand • wetted width: ~40 m

Table A3.2: Station Locations and Field Measurements taken at Buttle Lake and Brewster Lake Stations

Station I.D.	Latitude [1]	Longitude [2]	Depth (ft)	Temperature (°C)	D.O. (mg/L)	Water pH (units)	Sediment Eh (mV)	Conductivity (µmhos/cm)
MR1	125°35'12"	50°06'00"	surface	18.0	9.4			
			100	8.0	10.8	6.54	110	30
MR2	125°35'14"	50°06'01"	surface	18.0	9.6			
			103	8.0	10.7		95	
MR3	125°35'15"	50°06'04"	surface	18.0	7.5			
			103	8.0	9.3	6.66		27
MR4	125°35'04"	50°05'58"	surface	18.0	8.9			
			135	8.0	10.2			
MR5	125°35'11"	50°06'07"	surface	18.0	9.1			
			130	8.0	10.3			
MR6	125°34'54"	50°06'30"	surface	18.0	9.7			
			125	8.0	10.7			
MR7	125°34'54"	50°06'32"	surface	18.0	9.5			
			124	7.5	9.9	6.70		27
MN4	125°33'46"	49°35'22"	surface	17.0	8.1	7.13		60
			127	8.0	10.4	7.05		65
MN5	125°33'12"	49°36'05"	surface	17.0	7.9			
			137	8.0	10.4		160	
MN6	125°32'39"	49°37'19"	surface	17.0	8.3			
			131	8.0	10.2			
MN7	125°32'34"	49°37'31"	surface	17.0	8.1	7.15		60
			130	8.0	10.4	7.08		65
MN8	125°32'42"	49°37'35"	surface	17.0	8			
			131	8.0	10.1		56	
MN9	125°32'41"	49°37'38"	surface	17.0	8.3			
			134	8.0	10.3		66	
MN10	125°32'27"	49°38'00"	surface	17.0	8.3	7.15		60
			137	8.0	10.1	7.09	115	65
MF1	125°37'02"	49°47'55"	surface	17.0	9.8	7.30		56
			135	7.5	11.1	7.23		60
MF2	125°36'56"	49°47'51"	surface	17.0	9.8			
			123	7.5	10.9			
MF3	125°36'39"	49°49'28"	surface	17.0	9.6	7.30		56
			137	7.5	10.8	7.25		60
MF4	125°36'39"	49°49'28"	surface	17.0	9.9			
			129	7.5	10.6		275	
MF5	125°36'29"	49°49'21"	surface	17.0	9.8			
			115	7.5	10.8		195	
MF6	125°36'22"	49°49'09"	surface	17.0	9.9			
			125	7.5	10.7		-30	
MF7	125°36'21"	49°49'02"	surface	17.0	9.8	7.30		56
			125	7.5	11.1	7.15	175	59

[1] Latitude - measurements are in degrees North
[2] Longitude - measurements are in degrees West

Table A3.3: Station Locations and Field Measurements taken at Myra Creek Stations

Station I.D.	Temperature (°C)	D.O. (mg/L)	Water pH (units)	Conductivity (µmhos/cm)
MCR1	11.0	10.2	7.05	25.5
MCR2	10.0	10.1	8.01	24.1
MCR3	11.0	10.3	7.50	22.3
MCR4	11.0	10.2	7.06	23.6
MCR5	11.0	9.9	6.90	22.7
MCR6	11.0	10.2	7.15	20.8
MCR7	11.0	10.5	7.73	22.9
MCR8	11.0	10.8	8.03	17.2
MCR9	11.0	10.6	7.15	22.3
MCR10	11.0	10.4	7.18	21.7
MCE1	11.0	10.3	7.78	172.9
MCE2	11.0	10.2	8.05	168.4
MCE3	11.0	10.2	7.70	176.6
MCE4	11.0	10.8	7.40	150.9
MCE5	11.0	11.3	7.30	179.6
MCE6	11.0	11.2	7.87	167.7
MCE7	11.0	11.2	8.05	172.3
MCE8	11.0	12.7	11.54	176.4
MCE9	11.0	11.6	ND[1]	176.2
MCE10	11.0	10.2	ND	184.5

[1] ND = no data - equipment failure

Table A3.4: LABORATORY METHODS AND BOTTLE/PRESERVATIVE PROCEDURES USED IN WATER SAMPLE ANALYSIS (as provided by Philip Analytical Services)

Parameters	Method	Bottle Requirement	Preservative Type	Max. Holding Time
Acidity	Standard Methods (17th ed.) No. 2310B U.S. EPA Method No. 305.1	250 ml Bottle Glass	no preservative	14 days
Alkalinity	Standard Methods (17th ed.) No. 2320	250 ml Bottle Glass	no preservative	14 days
RCAP Calculations Total Dissolved Solids(Calculated) Hardness(as CaCO3) Bicarbonate(as CaCO3, calculated) Carbonate(as CaCO3, calculated) Cation Sum Anion Sum Ion Balance	MDS Internal Reference Method			
Colour	U.S. EPA Method No. 110.3(Modified) (Reference-Std Methods(17th)2120CMod)	100 ml Bottle Glass	no preservative	48 hours
Specific Conductance	U.S EPA Method No. 120.1	100 ml Bottle Glass	no preservative	28 days
Manual Conventionals for RCP(pH,Turb,Conduct,Color) pH Turbidity	U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3	250 ml Bottle HDPE	no preservative	
Hardness	U.S. EPA Method No. 130.2	250 ml Bottle Glass	no preservative	6 months
Ion Balance		250 ml Bottle HDPE	HNO3 to pH < 2	14 days
pH, Hydrogen Ion Activity	U.S. EPA Method No. 150.1	100 ml Bottle Glass	no preservative	
Total dissolved Solids	U.S. EPA Method No. 160.1	1 L Bottle Glass	no preservative	7 days
Total Suspended Solids	U.S. EPA Method No. 160.2	500 ml Bottle Glass	no preservative	7 days
Turbidity, UltraViolet	U.S. EPA Method No. 180.1	100 ml Bottle Glass	no preservative	48 hours
RCAP MS Package, 8 Element ICPAES Scan B, Fe, P, Zn, Ca, Mg, K, Na	U.S. EPA Method No. 200.7	125 ml Bottle HDPE 250 ml Bottle HDPE	HNO3 to pH < 2 no preservative	
ICP-MS 25 Element Scan, Clean Water Package Al, Sb, As, Ba, Be, Bi, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, As, Sr, Th, Sn, Ti, U, V, B, Fe, Zn	U.S. EPA Method No. 200.8(Modification)	250 ml Bottle HDPE 125 ml Bottle HDPE	no preservative HNO3 to pH < 2	
Alkalinity for RCAP Packages 30, 50 and MS	U.S. EPA Method No. 310.2	250 ml Bottle HDPE	no preservative	14 days
Anions for RCAP 50 and MS(Cl,NO2,NO3,o-PO4 & SO4)	U.S. EPA Method No. 300.0 or U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.	250 ml Bottle HDPE	no preservative	48 hours
Dissolved Organic Carbon, as Carbon for RCAP	MOE Method No. ROM - 102ACE(Modified)	100 ml Bottle Glass	no preservative	3 days
Ammonia for RCAP Packages 30, 50 and MS	ASTM Method No. D1426-79 C Refer - Method No. 1100106 Issue 122289	100 ml Bottle Glass 250 ml Bottle HDPE	H2SO4 to pH < 2 no preservative	28 days
Organic Nitrogen(TKN - NH3)	U.S. EPA Method No. 350.1 U.S. EPA Method No. 351.1	250 ml Bottle Glass	H2SO4 to pH < 2	28 days
Mercury, Cold Vapour AA	U.S. EPA SW846 Method No. 7470A Standard Methods(18th ed.) No. 3112B	100 ml Bottle Glass	HNO3 to pH < 2 + 5% K2CR207	7 days

APPENDIX 4

Figures and Tables Illustrating the Hypothesis Testing Results

Myra Falls: Hypothesis 1

Sediment Toxicity: comparison of endpoints as tools

Tool: *Chironomus* and *Hyalella* mortality comparison

Source	SS	df	MS	F Ratio	P
Among Reach	32.430	2	16.215	98.700	**4.09E-15**
Among Tools	1.120	1	1.120	6.817	**0.013**
Reach*Tool	0.610	2	0.305	1.857	0.171
Error	5.750	35	0.164		

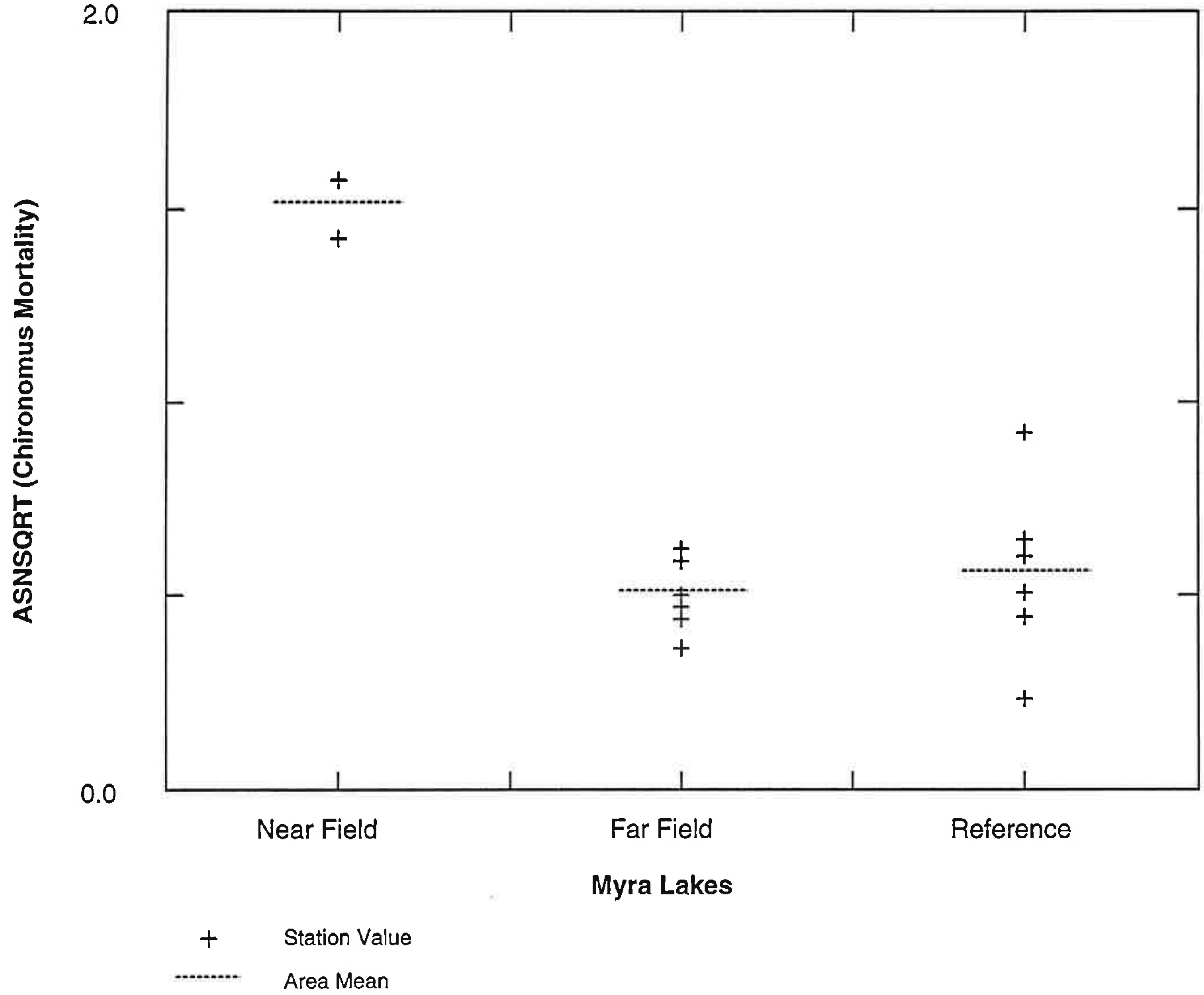
Comparisons between *Tubifex* mortatilty and *Chironomus* and *Hyalella* not conducted due to very low level of mortality in *Tubifex* tests

Tool: *Tubifex* Reproduction - Number of Cocoons/Adult vs Number of Young/Adult[1]

Source	SS	df	MS	F Ratio	P
Among Reach	1.504	2	0.752	9.660	**4.38E-04**
Among Tools	26.006	1	26.006	334.114	**1.11E-16**
Reach*Tool	0.705	2	0.353	4.529	**0.018**
Within Reach (Error)	2.802	36	0.078		

[1] Square root transformed

***Tubifex* Reproduction (Number young/Adult)**					
Among Reach	135.958	2	67.979	5.973	**0.011**
Within Reach (Error)	193.487	17	11.382		
***Tubifex* Mortality**					
Among Reach	2.02E-04	2	0.000	0.134	0.875
Within Reach (Error)	0.013	17	0.001		
***Tubifex* Cocoon Production/Adult**					
Among Reach	3.368	2	1.684	15.633	**1.40E-04**
Within Reach (Error)	1.831	17	0.108		
***Hyalella* Mortality (arcsine square root)**					
Among Reach	3.096	2	1.548	45.037	**1.61E-07**
Within Reach (Error)	0.584	17	0.034		
***Chironomus* Mortality (arcsine square root)**					
Among Reach	4.402	2	2.201	109.300	**1.97E-10**
Within Reach (Error)	0.342	17	0.020		
***Tubifex* %Hatch (arcsine square root)**					
Among Reach	0.004	2	0.002	0.518	0.605
Within Reach (Error)	0.064	17	0.004		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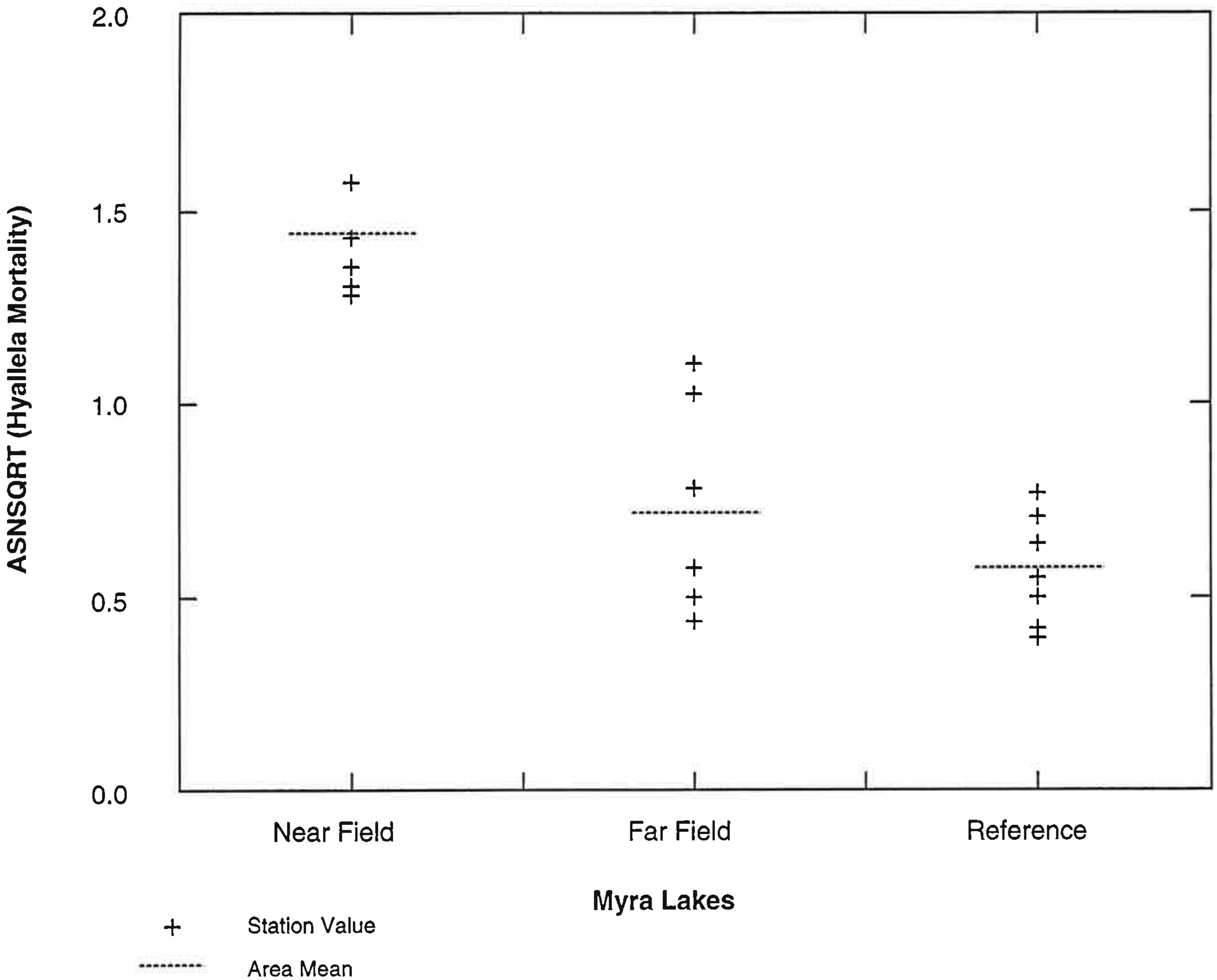
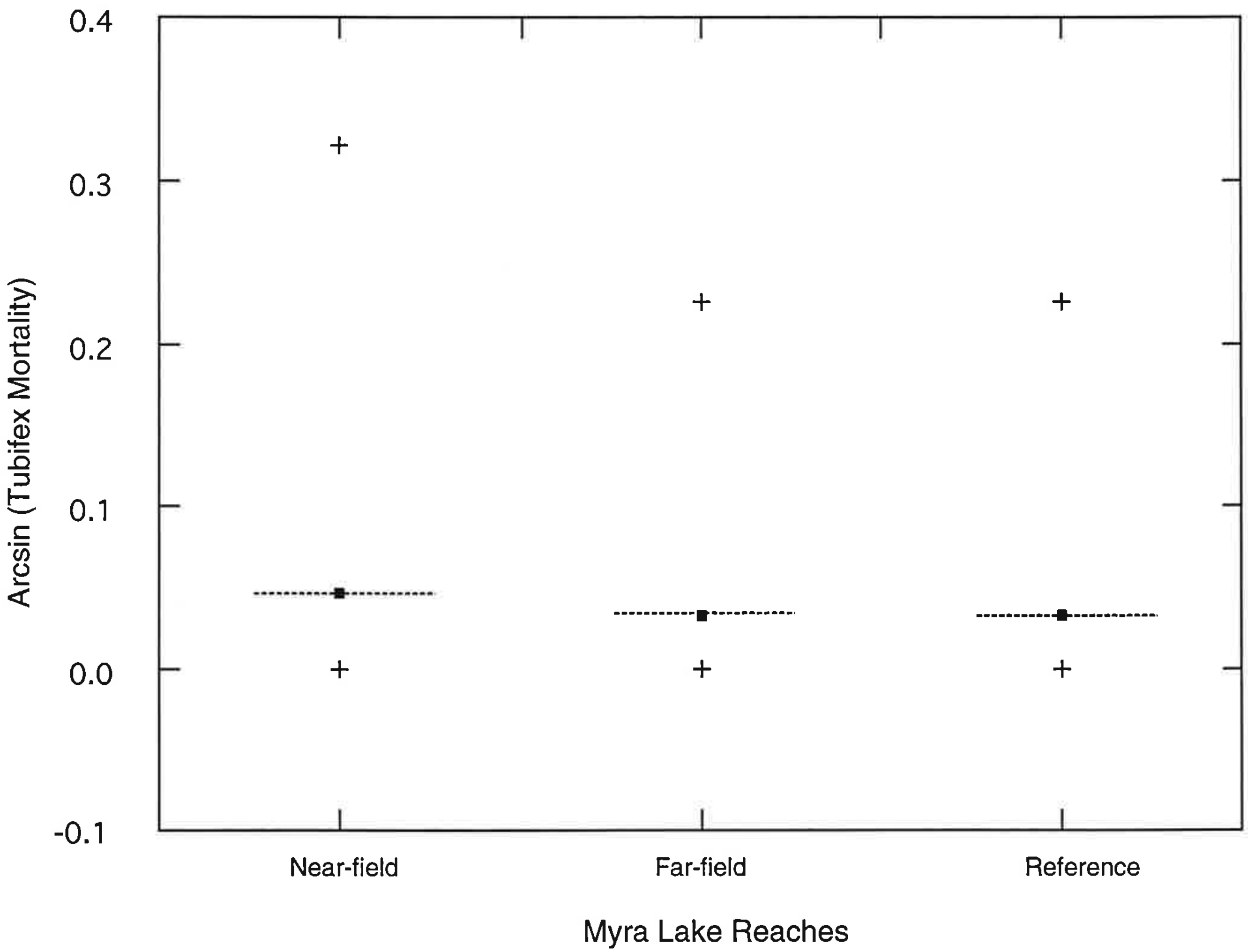
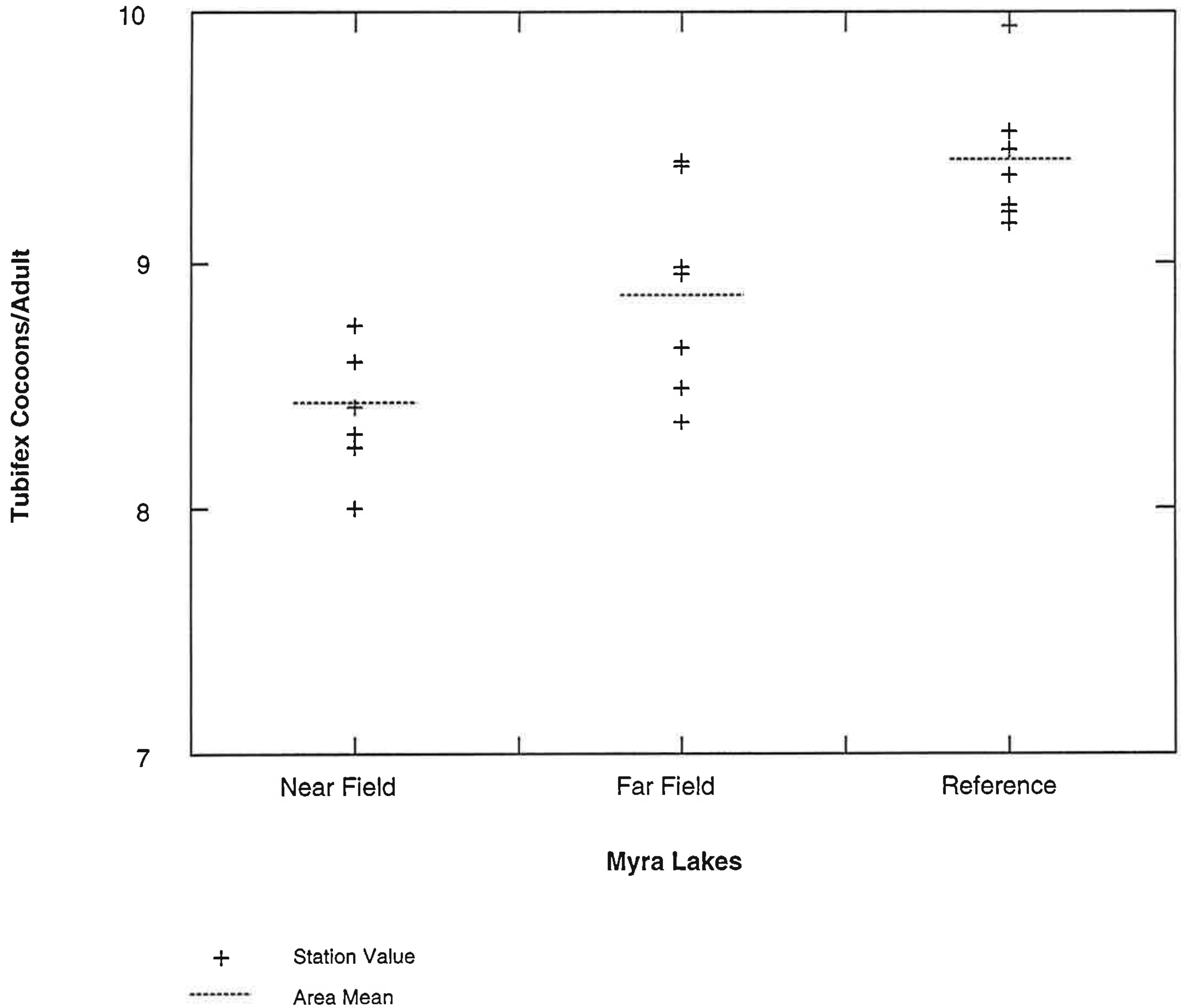
0.0
ASNSQRT (Chironomus Mortality)
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean

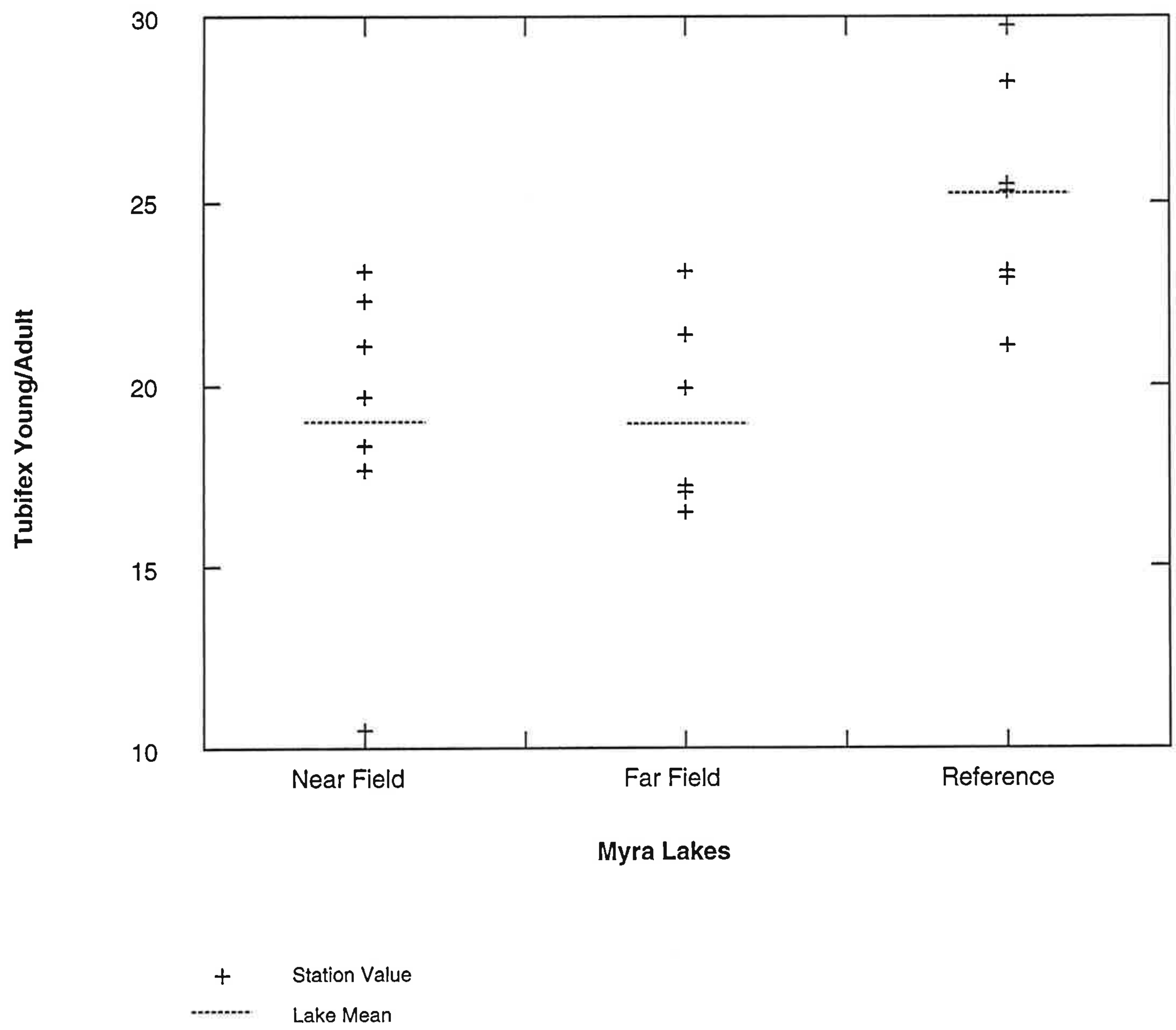


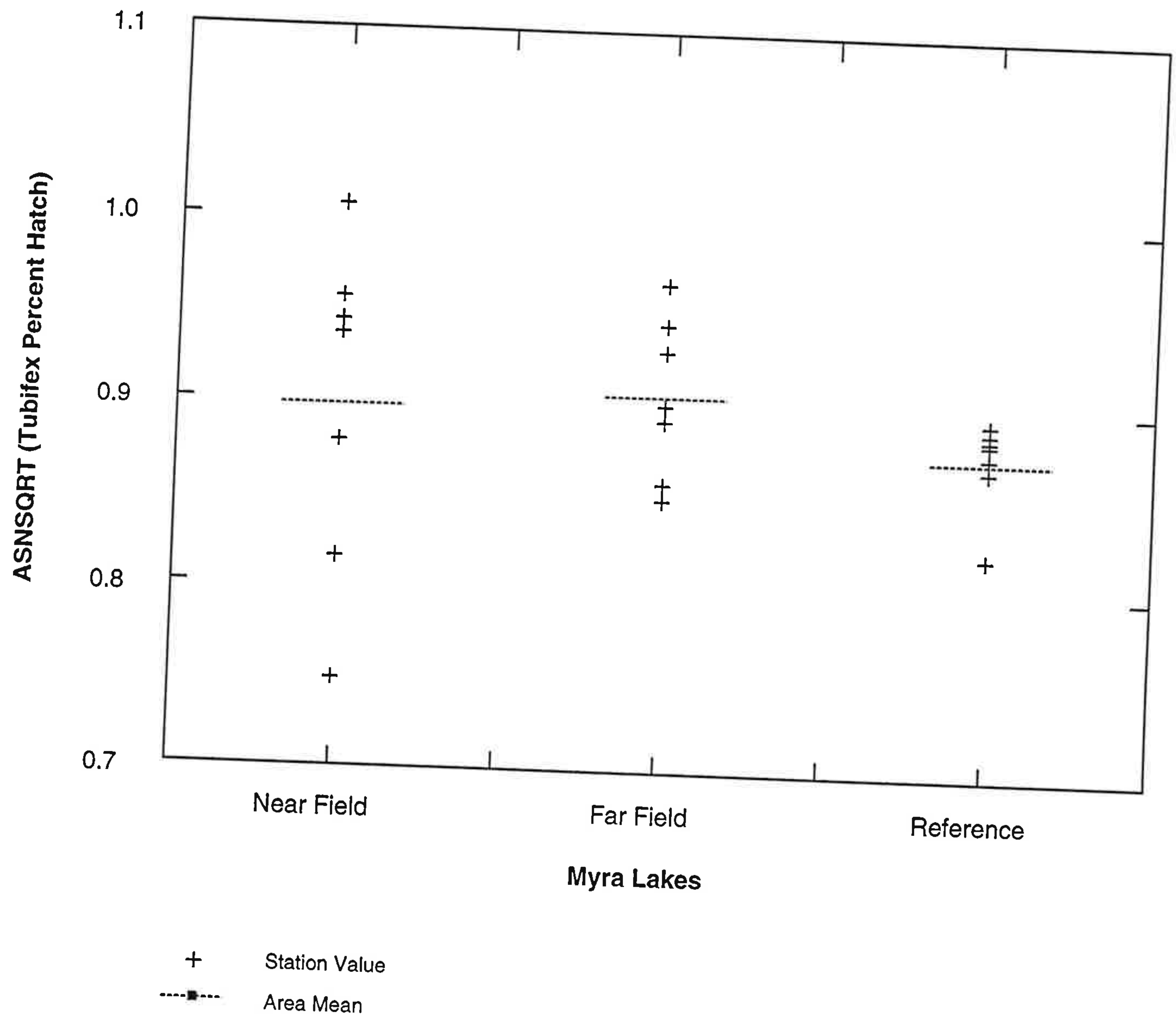
2.0
1.5
1.0
0.5
0.0
ASNSQRT (Hyallela Mortality)
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean


0.4
0.3
0.2
0.1
0.0
-0.1
Arcsin (Tubifex Mortality)
Near-field
Far-field
Reference
Myra Lake Reaches



Tubifex Cocoons/Adult
10
9
8
7
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean


30
25
20
15
10
Tubifex Young/Adult
Near Field
Far Field
Reference
Myra Lakes
Station Value
Lake Mean


1.1
1.0
0.9
0.8
0.7
ASNSQRT (Tubifex Percent Hatch)
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean

Myra Falls Benthos - Hypothesis #6

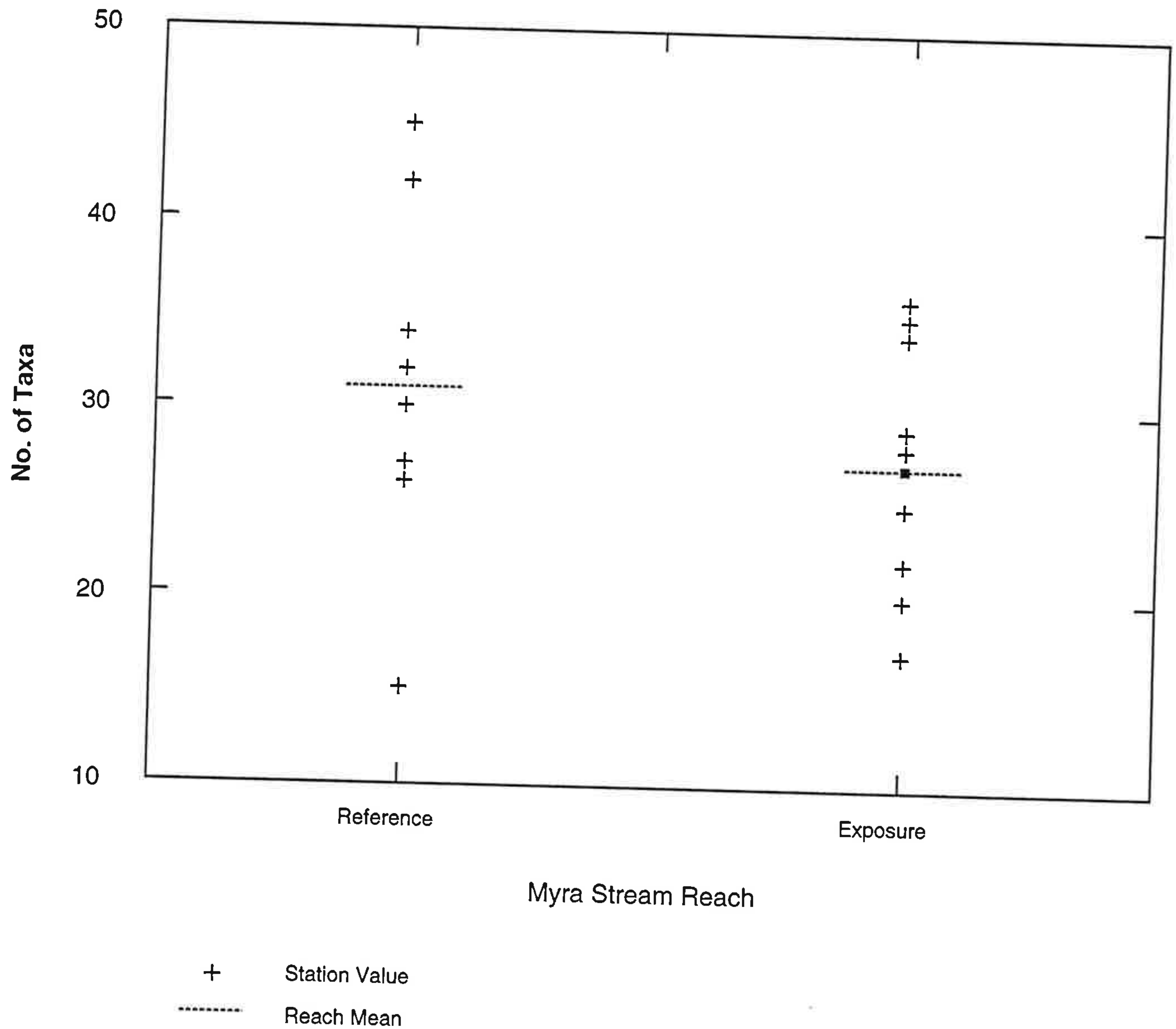
ANOVA for Among Creek Reach Differences in Myra Falls Benthic Comunity

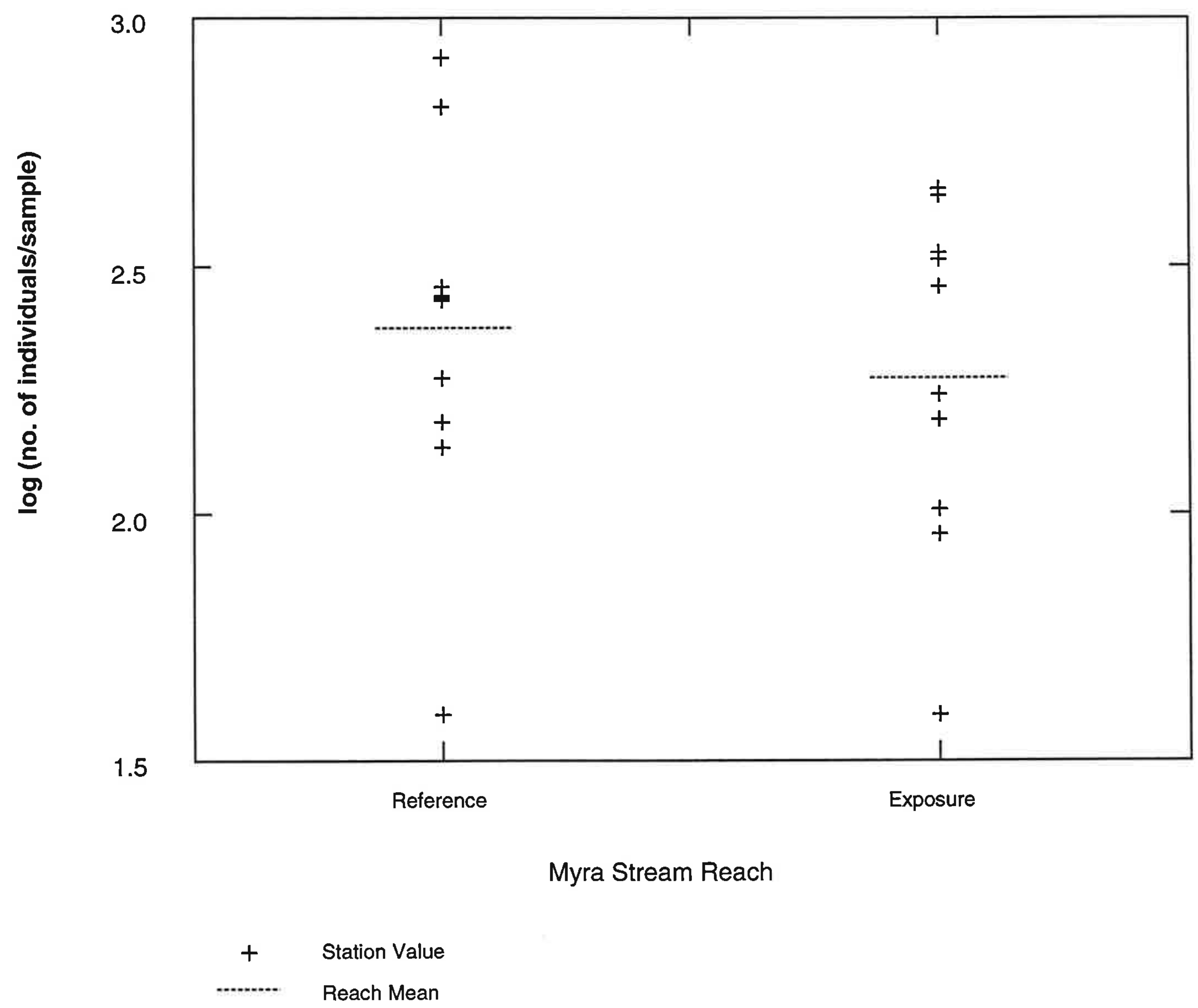
Source	SS	DF	MS	F	P
Log Benthic Density					
Among Reach	0.082	1	0.082	0.673	0.417
Within Reach (Error)	4.641	38	0.122		
Number of Taxa					
Among Reach	152	1	152	2.823	0.101
Within Reach (Error)	2046	38	53.8		
EPT Taxa					
Among Reach	194	1	193.6	15.250	**0.0004**
Within Reach (Error)	482	38	12.7		
%Chironomidae (arcsin sqrt)					
Among Reach	0.135	1	0.135	9.082	**0.005**
Within Reach (Error)	0.567	38	0.015		
%Ephemerellidae (arcsin sqrt)					
Among Reach	0.164	1	0.164	25.711	**1.10E-05**
Within Reach (Error)	0.242	38	0.006		
%Orthocladius+Cricotopus (arcsin sqrt)					
Among Reach	0.239	1	0.239	82.492	**4.62E-11**
Within Reach (Error)	0.110	38	0.003		

Myra Falls Benthos - Hypothesis #6

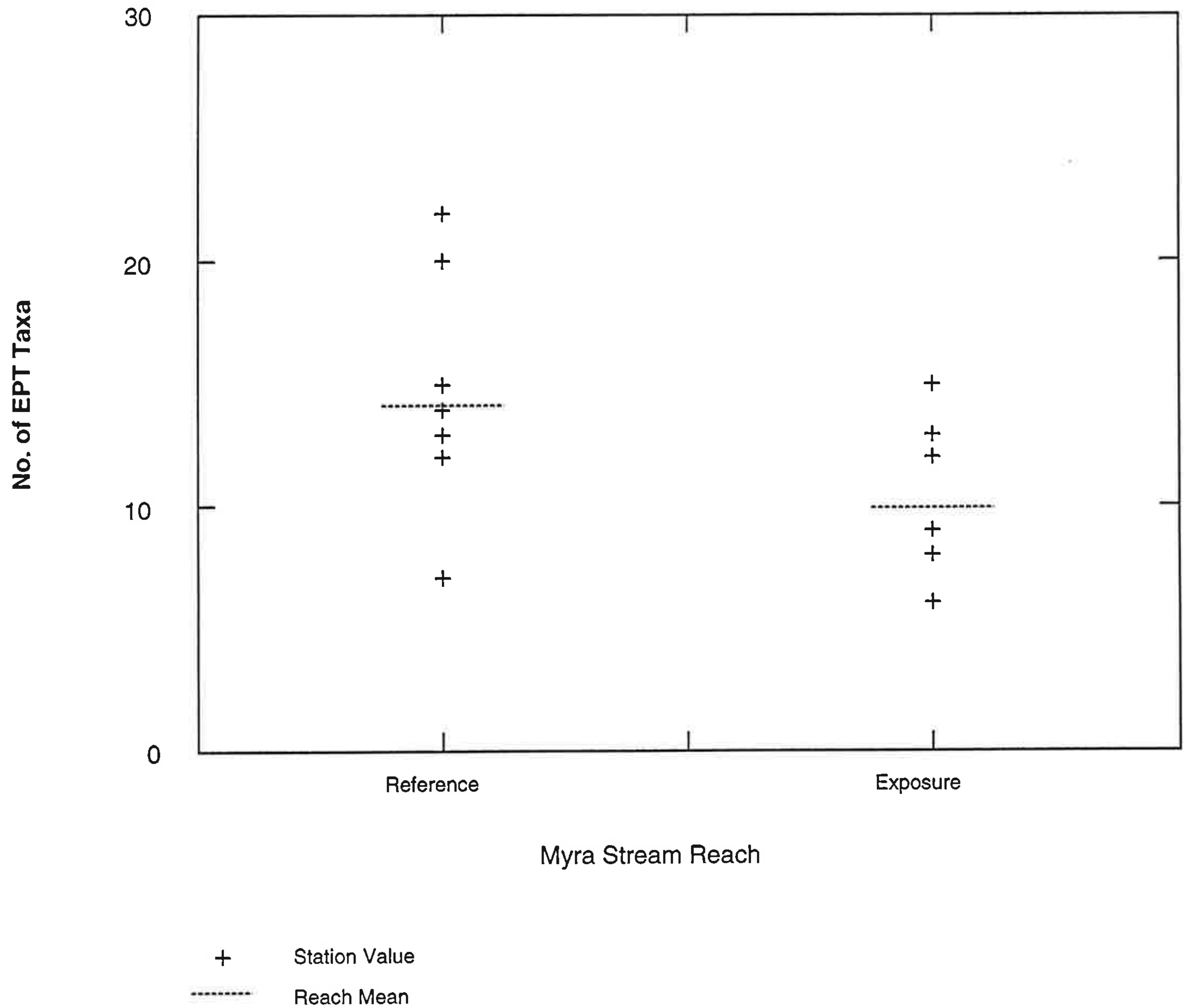
ANOVA for Among Lake Differences in Myra Falls Benthic Comunity

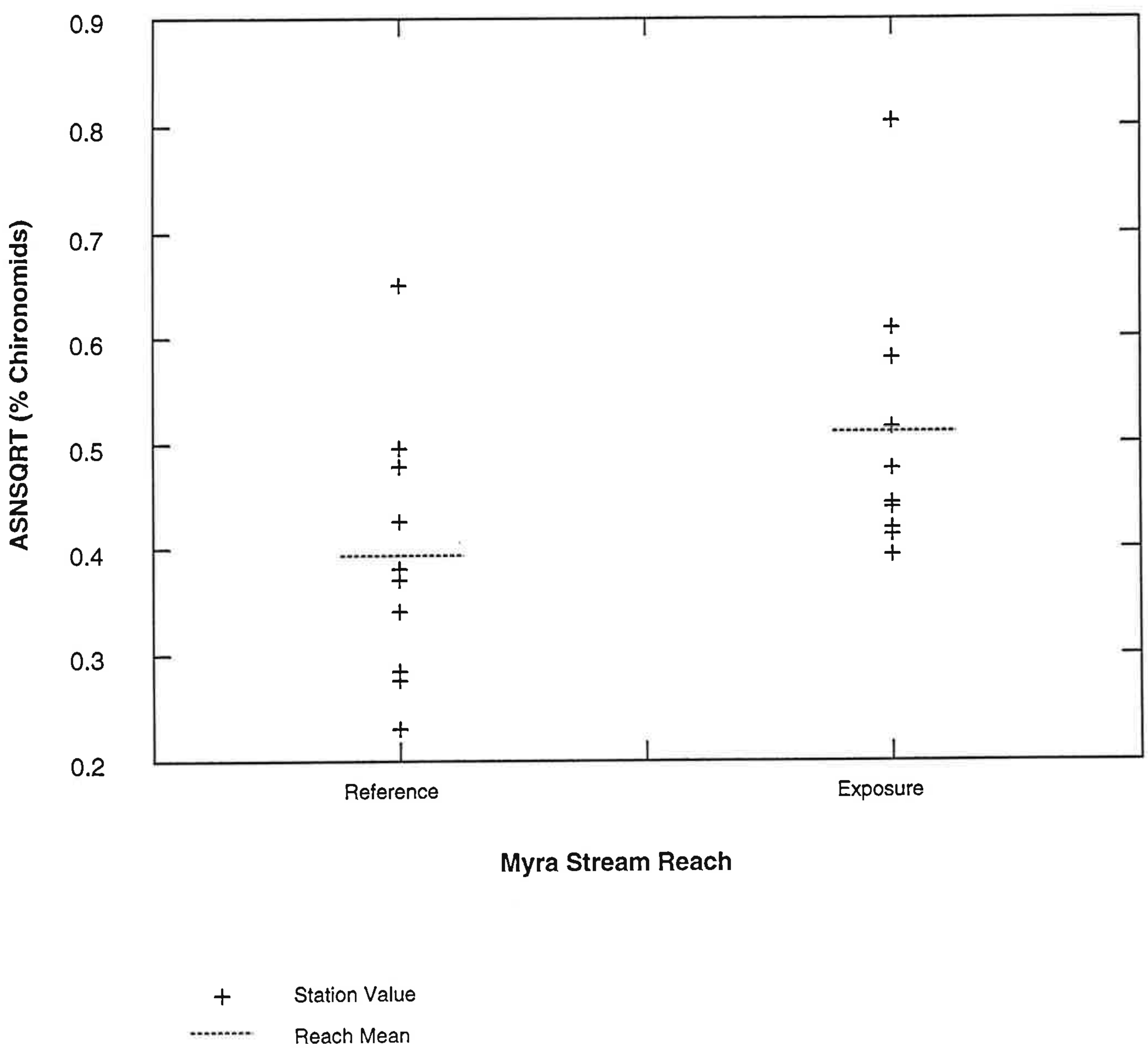
Source	SS	DF	MS	F	P
Number of Taxa					
Among Reach	1.795	2	0.898	0.079	0.924
Within Reach (Error)	1.93E+02	17	11.377		
%Chironomidae (arcsin sqrt)					
Among Reach	0.009	2	0.004665	0.276	0.762
Within Reach (Error)	0.287	17	0.0		
Log Benthic Density					
Among Reach	0.202	2	0.101161	3.389	0.058
Within Reach (Error)	0.507	17	0.0		
Harpacticoida Density					
Among Reach	3276.090	2	1638.045	55.158	**3.70E-08**
Within Reach (Error)	504.857	17	29.697		
Pisidium Density					
Among Reach	151.200	2	75.600	13.388	**3.22E-04**
Within Reach (Error)	96.000	17	5.647		


50
40
30
20
10
No. of Taxa
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean

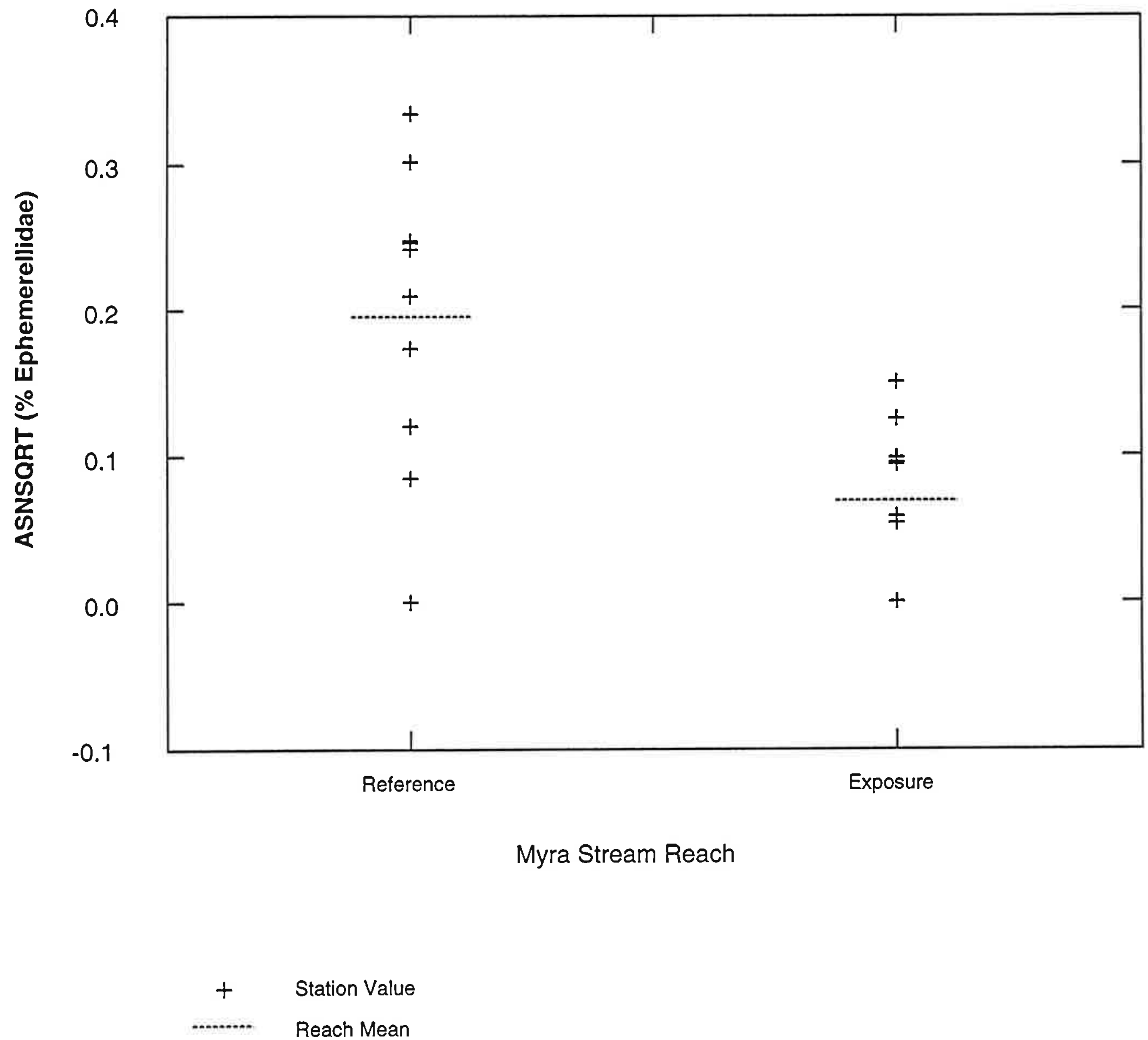


3.0
2.5
2.0
1.5
log (no. of individuals/sample)
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean

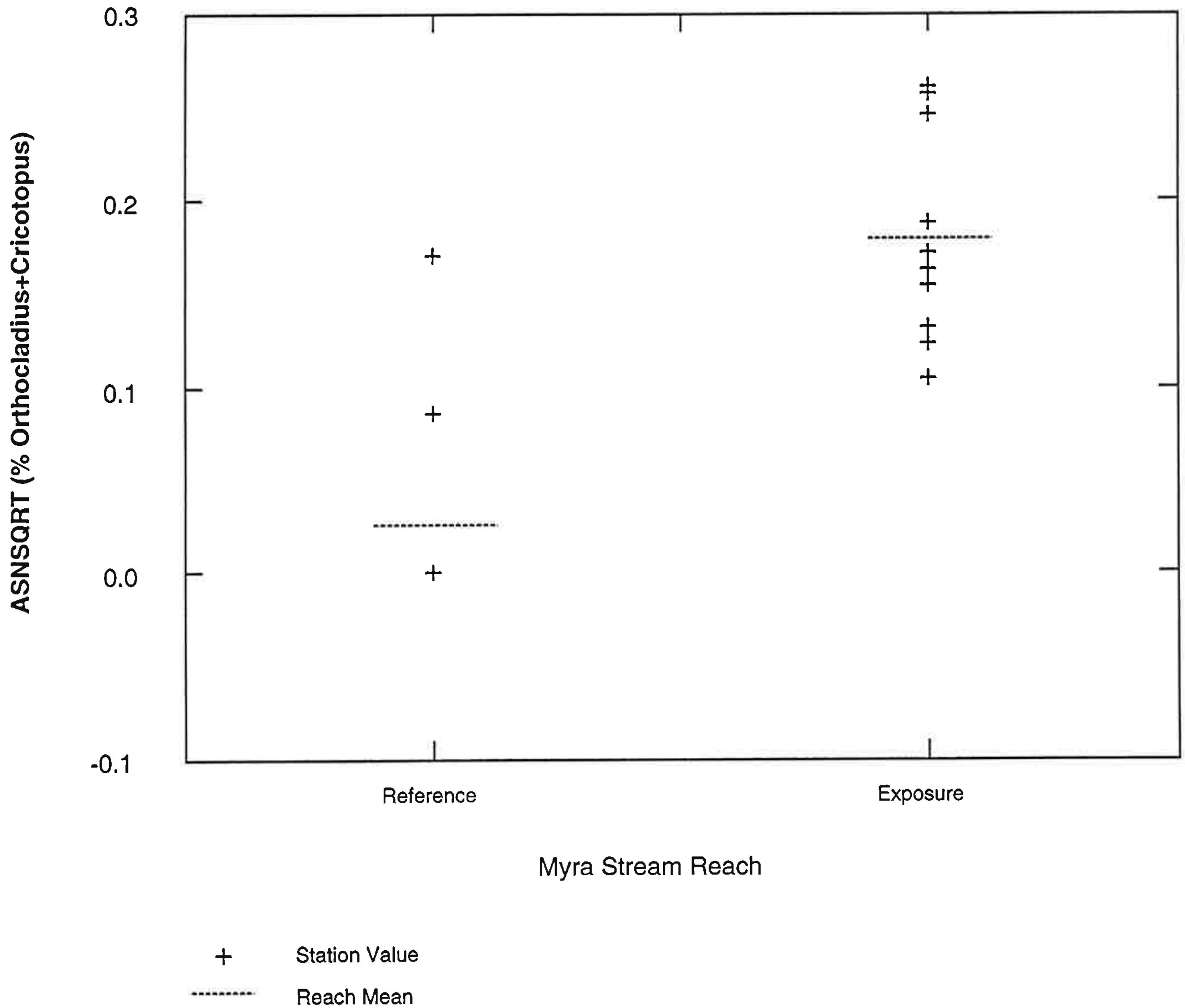

30
20
10
0
No. of EPT Taxa
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean



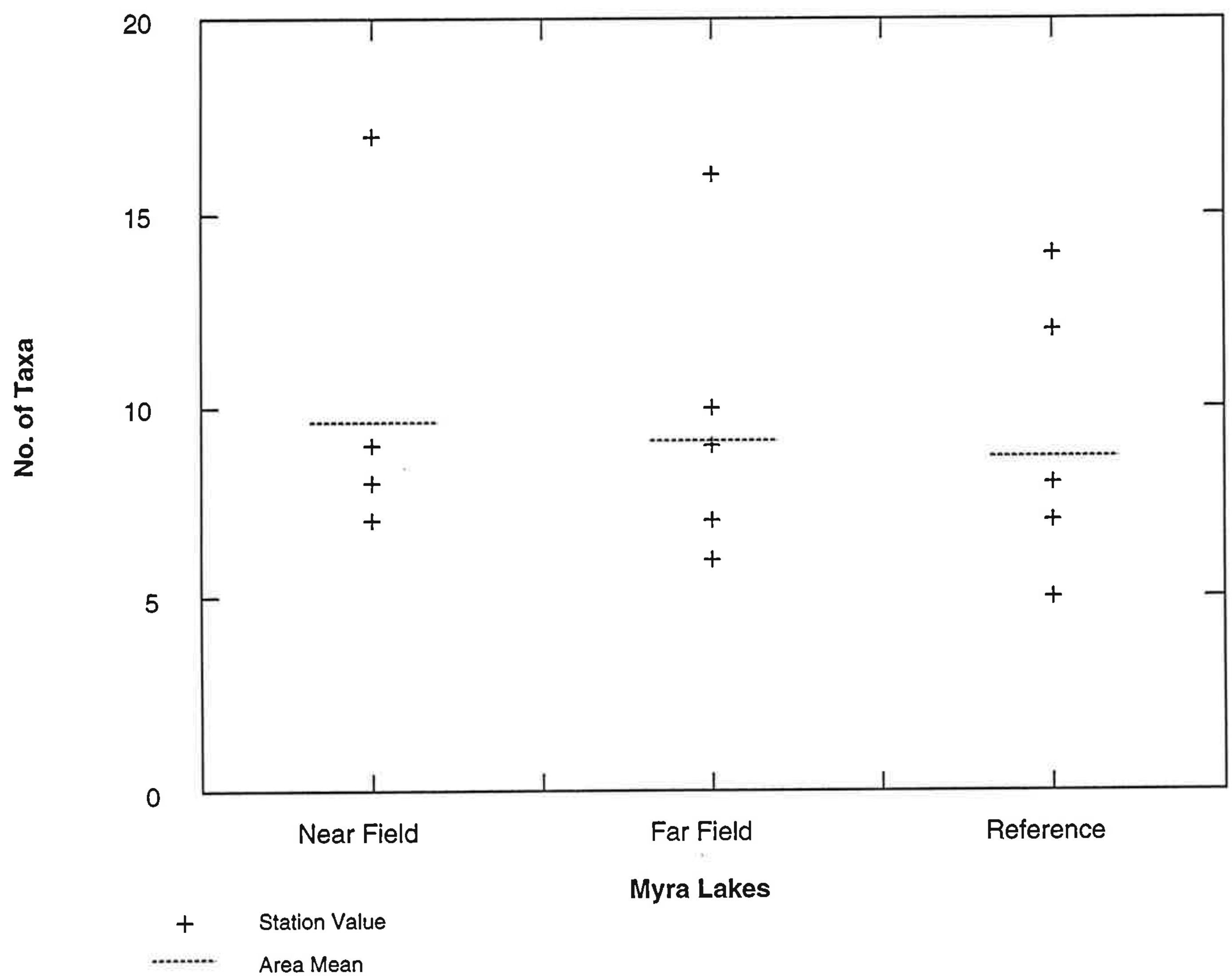
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
ASNSQRT (% Chironomids)
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean



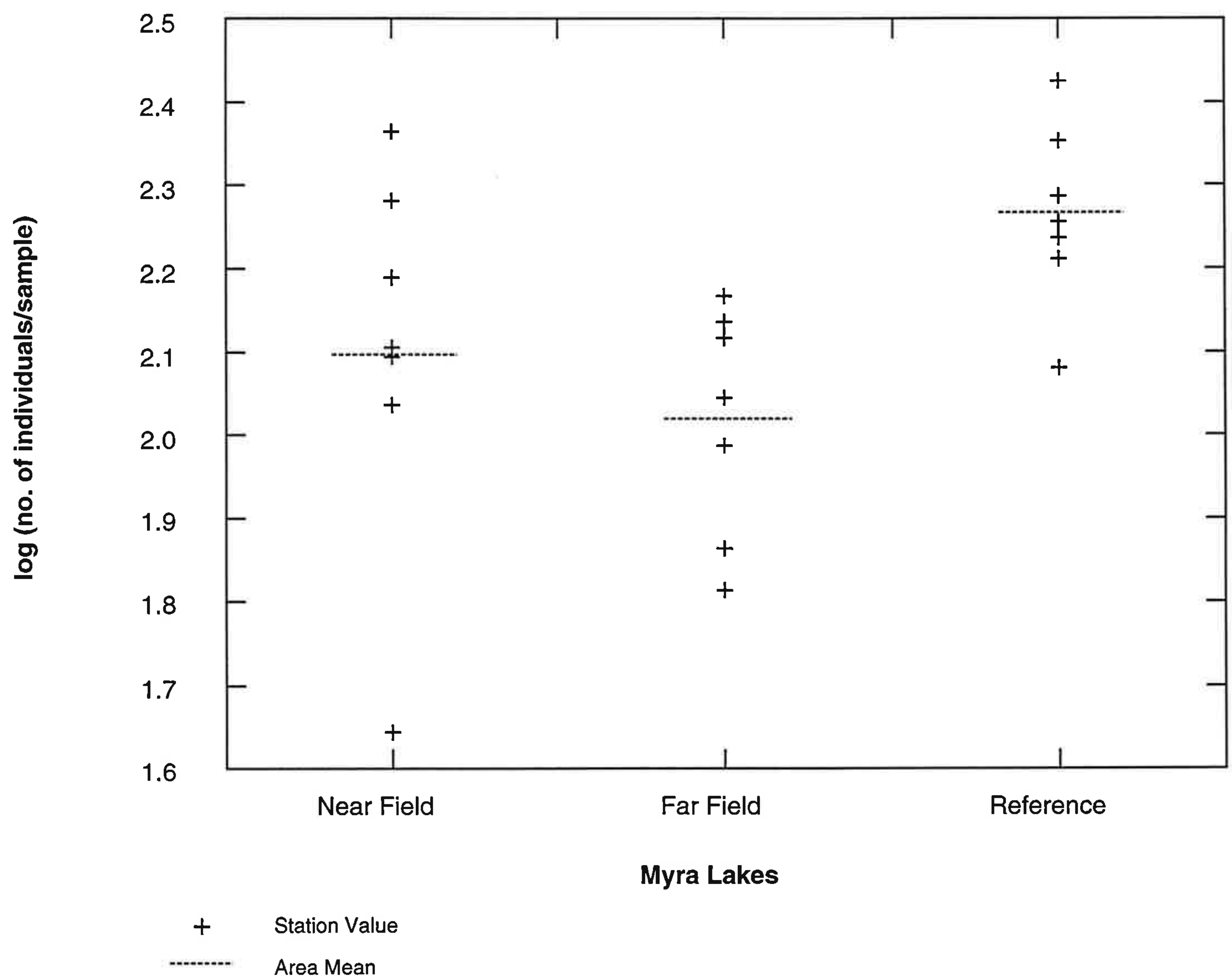
0.4
0.3
0.2
0.1
0.0
-0.1
ASNSQRT (% Ephemerellidae)
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean



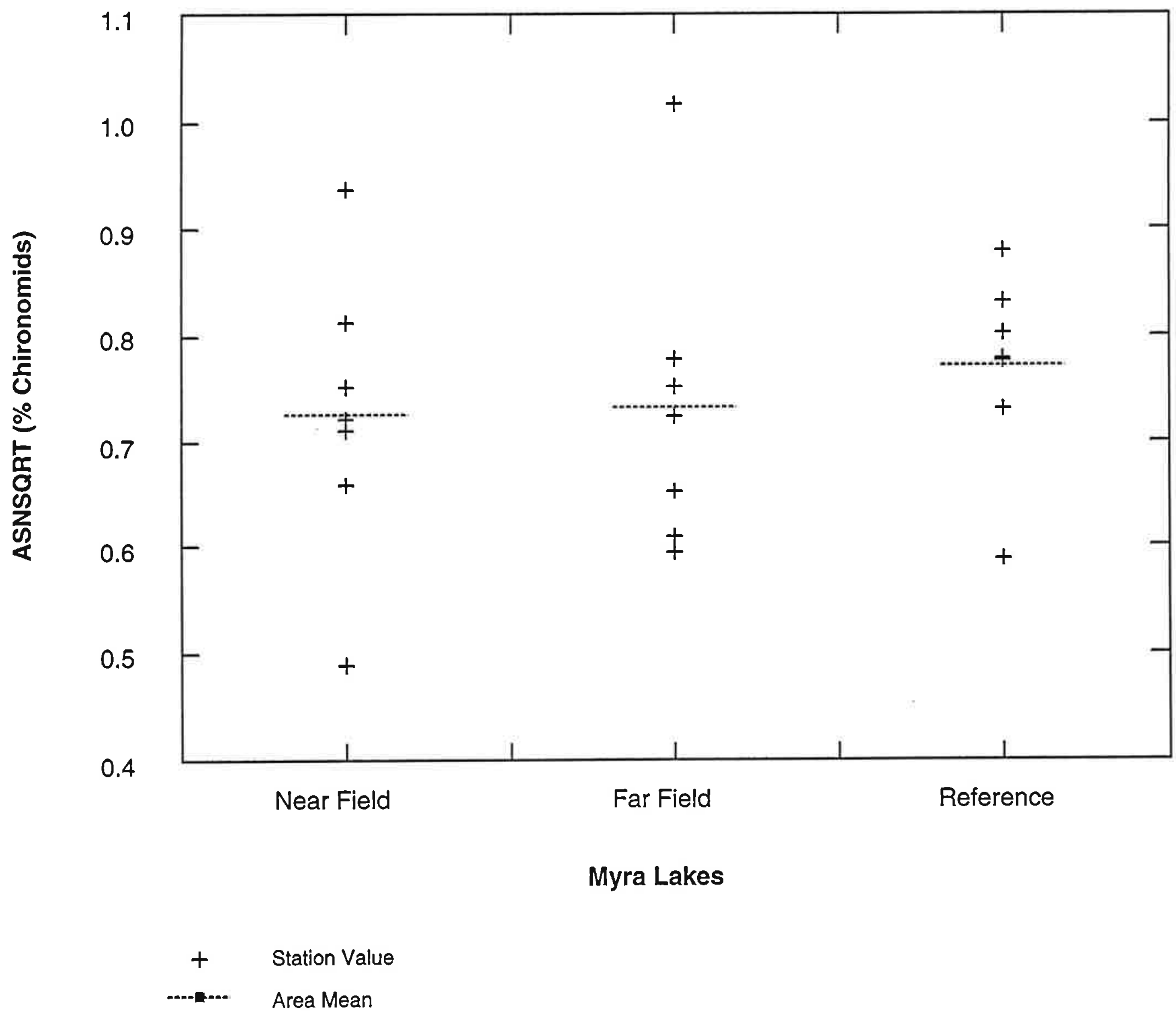
ASNSQRT (% Orthocladius+Cricotopus)
0.3
0.2
0.1
0.0
-0.1
Reference
Exposure
Myra Stream Reach
Station Value
Reach Mean



20
15
10
5
0
No. of Taxa
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean



2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
log (no. of individuals/sample)
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean



ASNSQRT (% Chironomids)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
Near Field
Far Field
Reference
Myra Lakes
Station Value
Area Mean

Myra Falls H10 correlation approach to sediment and benthic data at lake stations

a) matrix of Pearson correlations

	Benthic Community					Toxicity			
	log individuals	no. taxa	%chiron (asn Sqrt)	Harpacticoid Abundance (log)	*Pisidium* Abundance (log)	*Tubifex* repro. #Young/adult	*Tubifex* repro. #Cocoons/adult	%*Chironomus* Mortality (asn Sqrt)	%*Hyalella* Mortality (asn Sqrt)
log arsenic tot	-0.176	-0.045	-0.092	-0.459	-0.436	-0.401	-0.653	0.866	0.921
log cadmium tot	-0.260	0.166	-0.069	-0.650	-0.556	-0.455	-0.747	0.868	0.927
log cadmium par	-0.170	0.007	-0.062	-0.646	-0.549	-0.542	-0.799	0.793	0.791
log copper tot	-0.267	0.103	-0.023	-0.690	-0.590	-0.495	-0.746	0.849	0.925
log copper par	-0.256	-0.105	-0.065	-0.578	-0.537	-0.598	-0.865	0.708	0.687
log zinc tot	-0.339	0.129	-0.041	-0.747	-0.636	-0.527	-0.755	0.801	0.916
log zinc par	-0.288	0.066	-0.048	-0.777	-0.664	-0.594	-0.782	0.708	0.780

NOTE: Shading indicates significant correlation ($p<0.05$), however, significance level of individual correlations is suspect

b) matrix of significance tests of correlations

	Benthic Community					Toxicity			
	log individuals	no. taxa	%chiron (asn Sqrt)	Harpacticoid Abundance (log)	*Pisidium* Abundance (log)	*Tubifex* repro. #Young/adult	*Tubifex* repro. #Cocoons/adult	%*Chironomus* Mortality (asn Sqrt)	%*Hyalella* Mortality (asn Sqrt)
log arsenic tot	0.457	0.852	0.698	0.042	0.055	0.080	6.62E-04	8.05E-07	8.00E-09
log cadmium tot	0.269	0.485	0.773	0.002	0.011	0.044	4.92E-05	7.03E-07	4.00E-09
log cadmium par	0.473	0.975	0.794	0.002	0.012	0.014	7.05E-06	3.02E-05	3.35E-05
log copper tot	0.255	0.664	0.925	0.001	0.006	0.026	5.16E-05	2.19E-06	5.00E-09
log copper par	0.275	0.660	0.787	0.008	0.015	0.005	2.14E-07	4.84E-04	8.19E-04
log zinc tot	0.144	0.588	0.865	1.56E-04	0.003	0.017	3.75E-05	2.16E-05	1.50E-08
log zinc par	0.218	0.783	0.842	5.50E-05	0.001	0.006	1.39E-05	4.83E-04	4.93E-05

Cell Frequency = 21
Degrees of Freedom = 19
No data for partial arsenic - all values less than detection limit

Myra Lakes Hypothesis #10:
Correlations of Benthic Indices and Toxicity Tests with SEM/AVS

	SEM/AVS	
	Correlation	**Significance**
Benthic Indices		
No. of Individuals	0.034	0.884
log (no. ind.)	0.074	0.750
No. of Taxa	0.054	0.818
% Chironomidae	0.296	0.193
asn (% chir.)	0.288	0.205
No. of Harpacticoids	-0.208	0.366
No. of Pisidium	-0.185	0.422
Toxicity Endpoints		
Tubifex Cocoons/Adult	-0.130	0.573
Tubifex Young/Adult	0.209	0.363
Tubifex Reproduction Test	-0.025	0.913
Tubifex Mortality	-0.113	0.626
Chironomus Mortality	0.305	0.191
Hyalella Mortality	0.285	0.211

Myra Falls
H11 correlation approach to sediment toxicity and benthic data at lake stations

a) matrix of Pearson correlations

	Tubifex repro. #Young/adult	%*Chironomus* Mortality (asn Sqrt)	%*Hyalella* Mortality (asn Sqrt)
log individuals	0.443	-0.066	-0.284
no. taxa	0.125	0.001	0.014
asn pct chiron	-0.043	-0.125	0.051
harpacticoids	0.595	-0.365	-0.570
pisidium	0.480	-0.315	-0.550

b) matrix of significance tests of correlations

	Tubifex repro. #Young/adult	%*Chironomus* Mortality (asn Sqrt)	%*Hyalella* Mortality (asn Sqrt)
log individuals	0.051	0.782	0.225
no. taxa	0.601	0.996	0.953
asn pct chiron	0.859	0.599	0.832
harpacticoids	0.006	0.113	0.009
pisidium	0.032	0.176	0.012

(shaded) Statistically significant correlation at p = 0.05

Cell Frerquency = 21

Degrees of Freedom = 19

Summary of Significant Myra Falls Correlation Coefficients in the Lake Community

Monitoring Tool Used			Correlation Coefficient		
Chemistry	Toxicity	Biology	C-T	C-B	T-B
log cadmium tot	tubifex repro	pisidium	-0.455	-0.556	0.480
log copper tot	tubifex repro	pisidium	-0.495	-0.590	0.480
log cadmium par	tubifex repro	pisidium	-0.542	-0.549	0.480
log copper par	tubifex repro	pisidium	-0.598	-0.537	0.480
log zinc tot	tubifex repro	pisidium	-0.527	-0.636	0.480
log iron tot	hyal mort	pisidium	0.467	-0.678	-0.550
log cadmium tot	tubifex repro	harpacticoids	-0.455	-0.650	0.595
log zinc par	tubifex repro	pisidium	-0.594	-0.664	0.480
log copper par	hyal mort	pisidium	0.687	-0.537	-0.550
log copper tot	tubifex repro	harpacticoids	-0.495	-0.690	0.595
log copper par	tubifex repro	harpacticoids	-0.598	-0.578	0.595
log cadmium par	tubifex repro	harpacticoids	-0.542	-0.646	0.595
log copper par	hyal mort	harpacticoids	0.687	-0.578	-0.570
log zinc tot	tubifex repro	harpacticoids	-0.527	-0.747	0.595
log cadmium par	hyal mort	pisidium	0.791	-0.549	-0.550
log zinc par	tubifex repro	harpacticoids	-0.594	-0.777	0.595
log cadmium tot	hyal mort	pisidium	0.927	-0.556	-0.550
log zinc par	hyal mort	pisidium	0.780	-0.664	-0.550
log cadmium par	hyal mort	harpacticoids	0.791	-0.646	-0.570
log copper tot	hyal mort	pisidium	0.925	-0.590	-0.550
log zinc tot	hyal mort	pisidium	0.916	-0.636	-0.550
log cadmium tot	hyal mort	harpacticoids	0.927	-0.650	-0.570
log zinc par	hyal mort	harpacticoids	0.780	-0.777	-0.570
log copper tot	hyal mort	harpacticoids	0.925	-0.690	-0.570
log zinc tot	hyal mort	harpacticoids	0.916	-0.747	-0.570

Relative Contributions of Physical-Chemical Variables to Sediment Principal Components at Myra Falls

	Principal Components		
	1	2	3
%Variance Explained	64.4	20.4	5.7
Zinc	0.9792	0.1083	0.0761
Copper	0.9704	0.1876	0.0920
Cadmium	0.9436	0.2674	0.0625
Dry Bulk Density	0.9128	0.0441	-0.3462
Molybdenum	0.9107	0.3905	0.0403
Silver	0.8694	0.4824	0.0145
Magnesium	0.8418	-0.5189	0.0068
Arsenic	0.8393	0.4189	0.1140
%Fines	0.8350	-0.4288	-0.1166
Barium	0.8218	0.3290	0.2607
Strontium	0.7554	-0.3272	-0.2078
Lead	0.7492	0.6229	0.1602
Chromium	0.6456	-0.5508	0.3051
Nickel	0.4728	-0.8517	0.0635
%Gravel	0.3054	-0.5285	0.6935
Mercury	-0.1619	0.7914	0.1969
%Sand	-0.8330	0.4463	0.0785
%TOC	-0.9085	-0.0426	0.1814
%Moisture	-0.9162	0.0234	0.3429

Relative Contributions of Taxa Variables to Benthic Principal Components at Myra Falls

	Principal Components		
	1	2	3
%Variance Explained	22.9	16.1	13.5
Nematoda	0.16620	0.10333	-0.69745
Enchytaeidae	0.10443	-0.00002	-0.00478
Aulodrilus americanus	0.52232	0.48153	0.25715
Rhyacodrilus montana	0.02380	-0.57159	0.48111
Hydracarina	0.13877	-0.85155	0.07597
Harpacticoida	-0.81278	0.21736	0.32829
Ostracoda	-0.26973	-0.34850	-0.24144
Chironomid pupae	0.09742	0.18962	-0.48939
Chironomus	0.40339	-0.02654	0.64088
Micropsectra	0.62912	0.27677	0.47819
Protanypus	-0.53024	0.20856	0.31567
Heterotrissocladius	-0.73840	0.38797	0.12060
Parakiefferiella	0.12811	-0.80915	0.03379
Ablabesmyia	0.73999	0.25911	0.19521
Procladius	0.11819	0.21049	-0.47427
Thiennemannimyia	0.55724	0.38686	0.02822
Pisidium	-0.7332	0.22858	0.27535

MYRA FALLS
Sediment Quality Triad Correlations for Lakes

x variable	y variables	Multiple R	p
Sediment Chemistry x Benthos			
SPC1	BPC1, BPC2	0.684	0.003
SPC2	BPC1, BPC2	0.723	0.001
SPC1	*Harpacticoida, Heterotrissocladius, Pisidium, Ablabesmyia, Micropsectra*	0.823	<0.001
SPC2	*Harpacticoida, Heterotrissocladius, Pisidium, Ablabesmyia, Micropsectra*	0.447	0.135
Sediment Chemistry x Toxicity			
SPC1	*Chironomus, Hyalella, Tubifex*	0.919	<0.001
SPC2	*Chironomus, Hyalella, Tubifex*	0.721	0.007
Benthos x Toxicity			
BPC1	*Chironomus, Hyalella, Tubifex*	0.419	0.363
BPC2	*Chironomus, Hyalella, Tubifex*	0.671	0.020
Harpacticoida	*Chironomus, Hyalella, Tubifex*	0.730	0.004
Pisidium	*Chironomus, Hyalella, Tubifex*	0.648	0.023

(shaded) - statistically significant at p=0.05

MYRA FALLS
Sediment Quality Triad - Mantel's Tests
Comparison of Euclidean Distance Matrices

Matrix 1	Matrix 2	Z_M	p
Sediment Chemistry[1]	Benthic Community	0.423	0.0002
Sediment Chemistry[1]	Sediment Toxicity[2]	0.440	0.0002
Benthic Community	Sediment Toxicity[2]	0.762	0.0001

Results based on 10,000 Iterations

(shaded) - statistically significant at p=0.05

[2] based on *Chironomus*, *Hyalella* and *Tubifex* %mortality and growth

MYRA FALLS
SEDIMENT QUALITY TRIAD
BENTHIC COMMUNITY - EUCLIDEAN DISTANCE MATRIX

	Lake Sampling Station																			
	MN4	MN5	MN6	MN7	MN8	MN9	MN10	MF1	MF2	MF3	MF4	MF5	MF6	MF7	MR1	MR2	MR3	MR5	MR6	MR7
MN4	0																			
MN5	1.297874	0																		
MN6	1.820819	1.432189	0																	
MN7	1.576138	1.203213	1.668597	0																
MN8	1.713919	1.230163	1.204652	1.615388	0															
MN9	1.811762	1.241568	1.577239	1.479957	1.30505	0														
MN10	2.598388	2.260098	2.296632	2.681576	1.900179	1.859994	0													
MF1	3.006315	2.815418	3.040926	3.149641	2.716711	2.590248	2.32181	0												
MF2	2.395783	1.950214	2.191602	2.182705	1.805767	1.749752	1.763946	2.083886	0											
MF3	2.404175	2.18896	2.298373	2.349142	2.261564	1.929525	1.927026	2.170071	1.381095	0										
MF4	2.292139	1.874309	2.294377	2.018965	2.003267	1.808987	1.803014	2.417521	1.067784	1.408473	0									
MF5	3.267492	3.009755	3.099167	3.244326	2.793013	2.892887	2.730108	2.360091	2.186454	2.376521	2.549268	0								
MF6	2.379712	2.077118	2.586055	2.36775	2.133381	2.004804	1.959982	2.377778	1.537386	1.766218	1.252836	2.278152	0							
MF7	2.754035	2.530633	2.672711	2.773525	2.271065	2.461143	1.769398	2.440052	1.772315	1.936858	1.568311	2.855368	2.073188	0						
MR1	2.48956	2.065834	2.353167	2.468241	1.873537	1.917593	1.450048	2.355383	1.311605	1.768868	1.338903	2.591228	1.8467	1.567098	0					
MR2	2.896005	2.591968	2.965615	2.951382	2.683659	2.487255	2.317038	2.411259	2.032489	2.403464	2.208759	3.070397	2.292771	2.396988	2.026774	0				
MR3	2.770904	2.315362	2.63655	2.573074	2.361193	2.490433	2.476626	2.764194	1.769055	2.163245	1.464365	2.937033	2.126446	1.815885	1.694228	2.222004	0			
MR5	2.31227	1.948168	2.204339	2.153221	1.998222	1.886111	1.826416	2.307647	1.180027	1.123039	0.967101	2.543668	1.607409	1.582266	1.250986	2.065531	1.468411	0		
MR6	2.499474	2.044562	2.206969	2.242344	1.969131	2.053993	2.0883	2.51496	1.233212	1.675018	1.120155	2.510827	1.695655	1.76838	1.415818	2.084627	1.21653	0.88796	0	
MR7	2.558455	2.154307	2.425395	2.285304	2.044619	2.185163	2.149703	2.620995	1.343598	1.882429	1.137739	2.609247	1.753894	1.660523	1.42924	2.161077	1.470143	1.111245	0.85185	0

MYRA FALLS

SEDIMENT QUALITY TRIAD

SEDIMENT CHEMISTRY - EUCLIDEAN DISTANCE MATRIX

	Lake Sampling Station																			
	MN4	MN5	MN6	MN7	MN8	MN9	MN10	MF1	MF2	MF3	MF4	MF5	MF6	MF7	MR1	MR2	MR3	MR5	MR6	MR7
MN4	0																			
MN5	0.281927	0																		
MN6	0.094253	0.340047	0																	
MN7	0.218442	0.374225	0.197985	0																
MN8	0.196253	0.395024	0.098502	0.255410	0															
MN9	0.185367	0.305726	0.152222	0.233109	0.184246	0														
MN10	0.275217	0.388572	0.184009	0.225026	0.180234	0.182924	0													
MF1	0.749412	0.806506	0.674214	0.668262	0.694451	0.619686	0.590654	0												
MF2	0.679019	0.717746	0.599717	0.605488	0.613541	0.519435	0.499993	0.162552	0											
MF3	0.656965	0.668343	0.606627	0.587849	0.665177	0.560011	0.528744	0.269124	0.222473	0										
MF4	0.703538	0.742048	0.657418	0.657912	0.733016	0.658834	0.634897	0.321336	0.396006	0.246913	0									
MF5	0.716176	0.706429	0.665369	0.655836	0.729120	0.627545	0.589471	0.276541	0.318413	0.177867	0.141739	0								
MF6	0.573746	0.615567	0.516075	0.506099	0.563287	0.463734	0.437944	0.190552	0.200467	0.175886	0.228359	0.164514	0							
MF7	0.651451	0.692771	0.589071	0.680093	0.633592	0.541082	0.553184	0.301732	0.299339	0.327820	0.319848	0.278718	0.252293	0						
MR1	0.931008	0.887343	0.915682	0.925581	0.970520	0.794257	0.843459	0.628913	0.605412	0.591823	0.698783	0.564647	0.574682	0.560789	0					
MR2	0.950942	0.912262	0.938629	0.937275	1.000000	0.825848	0.863322	0.664879	0.643414	0.611701	0.733442	0.602184	0.610431	0.626113	0.080260	0				
MR3	0.917755	0.877119	0.898461	0.906704	0.956187	0.781436	0.823673	0.601295	0.575586	0.556231	0.664418	0.528874	0.543641	0.537697	0.000000	0.080539	0			
MR5	0.919831	0.874535	0.897594	0.912510	0.958631	0.796229	0.812455	0.656468	0.616412	0.581981	0.711682	0.570638	0.586397	0.591310	0.143866	0.081499	0.122598	0		
MR6	0.911429	0.871832	0.878842	0.884692	0.927896	0.777511	0.779085	0.574960	0.541468	0.524887	0.679276	0.532416	0.537515	0.559739	0.183415	0.129635	0.162864	0.079914	0	
MR7	0.850870	0.838809	0.825001	0.840590	0.887674	0.729131	0.747081	0.575126	0.551221	0.530541	0.639271	0.512932	0.503065	0.524840	0.169827	0.125980	0.143127	0.080451	0.121317	0

MYRA FALLS
SEDIMENT QUALITY TRIAD
SEDIMENT TOXICITY - EUCLIDEAN DISTANCE MATRIX

	Lake Sampling Station																			
	MN4	MN5	MN6	MN7	MN8	MN9	MN10	MF1	MF2	MF3	MF4	MF5	MF6	MF7	MR1	MR2	MR3	MR5	MR6	MR7
MN4	0																			
MN5	0.207084	0																		
MN6	0.150165	0.031444	0																	
MN7	0.310209	0.459275	0.406361	0																
MN8	0.000000	0.226895	0.168624	0.284490	0															
MN9	0.181711	0.167324	0.155623	0.485236	0.207476	0														
MN10	0.186412	0.110322	0.086261	0.350384	0.194933	0.206504	0													
MF1	0.806670	0.739683	0.742774	0.726512	0.805399	0.777280	0.635020	0												
MF2	0.662840	0.643602	0.635106	0.589525	0.660349	0.638600	0.528487	0.189827	0											
MF3	0.929485	0.814072	0.831955	0.902689	0.933415	0.863868	0.736797	0.192717	0.375935	0										
MF4	0.899175	0.765424	0.788684	0.901169	0.905339	0.821528	0.700455	0.248799	0.407901	0.064235	0									
MF5	0.873769	0.773992	0.784186	0.788503	0.872592	0.855099	0.680704	0.173250	0.370933	0.192737	0.229490	0								
MF6	0.686445	0.621756	0.626174	0.672510	0.689405	0.623926	0.527370	0.172300	0.119145	0.279499	0.291537	0.336237	0							
MF7	0.892877	0.786495	0.798334	0.809306	0.891907	0.874839	0.696734	0.213372	0.409896	0.208774	0.238292	0.012575	0.371683	0						
MR1	0.994615	0.853398	0.878224	0.981820	1.000000	0.924929	0.790393	0.315733	0.504202	0.114019	0.092616	0.231023	0.401926	0.223951	0					
MR2	0.886145	0.728621	0.759071	0.921389	0.894950	0.795416	0.681613	0.343068	0.479285	0.176354	0.084818	0.301080	0.352024	0.301060	0.134782	0				
MR3	0.958653	0.813735	0.839461	0.953011	0.964458	0.888054	0.753120	0.310513	0.490979	0.119647	0.075049	0.224805	0.385181	0.217781	0.014431	0.100372	0			
MR5	0.897406	0.733528	0.765544	0.933815	0.906332	0.808655	0.690148	0.369583	0.510259	0.202812	0.114433	0.308253	0.386012	0.303484	0.137532	0.012448	0.100996	0		
MR6	0.790945	0.592066	0.637618	0.920867	0.806838	0.661686	0.596035	0.552538	0.611268	0.441165	0.350951	0.530786	0.478654	0.530252	0.407643	0.249631	0.371199	0.242829	0	
MR7	0.959856	0.858419	0.873367	0.927439	0.963362	0.891413	0.776560	0.191990	0.359959	0.060297	0.136484	0.248917	0.270636	0.271353	0.186431	0.245603	0.200039	0.276727	0.498770	0

APPENDIX 5

Detailed Water and Sediment Quality Data

Table A5.1: Water Quality at Myra Falls

Parameter	LOQ	Units	MCE1-W Total	MCE1-W Total	MCE1-W Dissolved	MCE1-W Dissolved	MCE5-W Total	MCE5-W Dissolved	MCE10-W Total	MCE10-W Total
Date Sampled >			97/09/13	Replicate	97/09/13	Replicate	97/09/13	97/09/13	97/09/13	Replicate
Acidity(as CaCO3)	1	mg/L	8	6	-	-	12	-	8	-
Alkalinity(as CaCO3)	1	mg/L	15	14	-	-	15	-	15	-
Aluminum	0.005	mg/L	0.054	-	0.043	0.041	0.054	0.041	0.053	-
Ammonia(as N)	0.05	mg/L	0.08	0.09	-	-	0.07	-	0.07	-
Anion Sum	na	meq/L	2.25	-	-	-	2.18	-	2.2	-
Antimony	0.0005	mg/L	nd	-	nd	nd	nd	nd	nd	-
Arsenic	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Barium	0.005	mg/L	0.011	-	0.01	0.01	0.01	0.01	0.01	-
Beryllium	0.005	mg/L	nd	-	nd	nd	nd	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	15	-	-	-	15	-	15	-
Bismuth	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Boron	0.005	mg/L	0.01	0.01	nd	nd	0.013	nd	0.012	-
Cadmium	0.00005	mg/L	0.00057	-	0.00053	0.00053	0.00054	0.0005	0.00056	-
Calcium	0.1	mg/L	34.6	35	38	37.8	34.9	38	33.2	-
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	nd	-	nd	-
Cation Sum	na	meq/L	2.22	-	-	-	2.21	-	2.15	-
Chloride	1	mg/L	2	2	-	-	2	-	2	-
Chromium	0.0005	mg/L	nd	-	0.0005	0.0005	nd	0.0007	nd	-
Cobalt	0.0002	mg/L	0.0006	-	0.0005	0.0006	0.0005	0.0005	0.0006	-
Colour	5	TCU	nd	nd	-	-	nd	-	nd	-
Conductivity - @25øC	1	us/cm	220	220	-	-	200	-	220	-
Copper	0.0003	mg/L	0.0104	-	0.0075	0.0078	0.0094	0.0078	0.0103	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	2.7	2.3	-	2.7	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	0.8	na	-	0.7	-	-
Hardness(as CaCO3)	0.1	mg/L	102	-	-	-	102	-	98.8	-
Ion Balance	0.01	%	0.75	-	-	-	0.9	-	1.01	-
Iron	0.02	mg/L	0.04	-	0.04	0.04	0.04	0.06	0.04	-
Langelier Index at 20øC	na	na	-1.3	-	-	-	-1.08	-	-1.08	-
Langelier Index at 4øC	na	na	-1.7	-	-	-	-1.48	-	-1.48	-
Lead	0.0001	mg/L	nd	-	0.0006	0.0005	nd	0.0004	nd	-
Magnesium	0.1	mg/L	1.6	1.6	1.7	1.7	1.5	1.7	1.6	-
Manganese	0.0005	mg/L	0.192	-	0.178	0.181	0.179	0.178	0.19	-
Mercury	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0036	-	0.0036	0.0035	0.0037	0.0035	0.0034	-
Nickel	0.001	mg/L	0.002	-	0.002	0.002	0.002	0.002	0.002	-
Nitrate(as N)	0.05	mg/L	0.19	0.19	-	-	0.19	-	0.18	-
Nitrite(as N)	0.01	mg/L	0.01	0.01	-	-	0.01	-	0.01	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	nd	-	nd	-
pH	0.1	Units	7.4	7.5	-	-	7.6	-	7.6	-
Phosphorus, Dissolved	0.1	mg/L	-	-	nd	nd	-	nd	-	-
Phosphorus, Total	0.01	mg/L	nd	nd	0.02	0.02	nd	nd	nd	-
Potassium	0.5	mg/L	0.8	1.1	1.6	1.4	0.7	1.5	1	-
Reactive Silica(SiO2)	0.5	mg/L	3	3.1	-	-	3.1	-	3.1	-
Saturation pH at 20øC	na	units	8.69	-	-	-	8.69	-	8.71	-
Saturation pH at 4øC	na	units	9.09	-	-	-	9.09	-	9.11	-
Selenium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Silver	0.00005	mg/L	nd	-	nd	nd	nd	nd	nd	-
Sodium	0.1	mg/L	2.9	2.9	3.1	3.1	3	3.1	2.8	-
Strontium	0.005	mg/L	0.131	-	0.125	0.126	0.124	-	0.124	-
Sulphate	2	mg/L	90	90	-	-	87	-	88	-
Thallium	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd	-
Tin	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Titanium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	150	-	-	146	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.12	0.1	-	-	0.08	-	0.07	-
Total Suspended Solids	1	mg/L	nd	nd	-	-	nd	-	nd	-
Turbidity	0.1	NTU	0.3	0.3	-	-	0.2	-	0.3	-
Uranium	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd	-
Vanadium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd	-
Zinc	0.001	mg/L	0.372	-	0.369	0.356	0.346	0.345	0.367	-
Fluoride	0.02	mg/L	nd	nd	-	-	0.1	-	nd	-

Table A5.1: Water Quality at Myra Falls

Parameter	LOQ	Units	MCE10-W Dissolved	MCR1-W Total	MCR1-W Dissolved	MCR1-W Total	MCR1-W Dissolved	MCR5-W Total	MCR5-W Dissolved	MCR10-W Total
Date Sampled >			97/09/13	97/09/13	97/09/13	field dup.	field dup.	97/09/13	97/09/13	97/09/13
Acidity(as CaCO3)	1	mg/L	-	2	-	2	-	2	-	2
Alkalinity(as CaCO3)	1	mg/L	-	13	-	12	-	13	-	13
Aluminum	0.005	mg/L	0.04	0.023	0.022	0.024	0.023	0.025	0.025	0.023
Ammonia(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-	nd
Anion Sum	na	meq/L	-	0.301	-	0.281	-	0.301	-	0.302
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	0.01	nd	nd	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	13	-	12	-	13	-	13
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	0.012	nd	0.031	nd	0.012	nd	0.009
Cadmium	0.00005	mg/L	0.00052	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	mg/L	36.7	4.5	4.8	4.5	4.8	4.4	4.8	4.5
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	nd	-	nd	-	nd
Cation Sum	na	meq/L	-	0.274	-	0.276	-	0.28	-	0.275
Chloride	1	mg/L	-	nd	-	nd	-	nd	-	nd
Chromium	0.0005	mg/L	0.0006	nd	nd	nd	nd	nd	nd	0.0008
Cobalt	0.0002	mg/L	0.0006	nd	nd	nd	nd	nd	nd	nd
Colour	5	TCU	-	nd	-	nd	-	nd	-	nd
Conductivity - @25øC	1	us/cm	-	27	-	27	-	26	-	27
Copper	0.0003	mg/L	0.0079	nd	0.0008	nd	0.0008	nd	0.0013	nd
Dissolved Inorganic Carbon(as C)	0.2	mg/L	2.7	-	1.8	-	1.5	-	1.7	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	1	-	0.8	-	0.9	-	0.8	-
Hardness(as CaCO3)	0.1	mg/L	-	12.7	-	12.8	-	12.7	-	12.8
Ion Balance	0.01	%	-	4.64	-	0.88	-	3.7	-	4.56
Iron	0.02	mg/L	0.05	0.03	0.03	0.03	0.03	0.03	0.04	0.02
Langelier Index at 20øC	na	na	-	-1.8	-	-1.89	-	-1.28	-	-1.86
Langelier Index at 4øC	na	na	-	-2.2	-	-2.29	-	-1.68	-	-2.26
Lead	0.0001	mg/L	0.0003	nd	nd	nd	nd	nd	0.0002	nd
Magnesium	0.1	mg/L	1.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Manganese	0.0005	mg/L	0.19	nd	nd	nd	nd	0.0005	0.0007	nd
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0032	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Nickel	0.001	mg/L	0.002	nd	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-	nd
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-	nd
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-	nd
pH	0.1	Units	-	7.8	-	7.8	-	8.3	-	7.8
Phosphorus, Dissolved	0.1	mg/L	nd	-	nd	-	nd	-	nd	-
Phosphorus, Total	0.01	mg/L	0.02	nd	nd	nd	0.01	nd	nd	nd
Potassium	0.5	mg/L	1.7	nd	nd	nd	nd	nd	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	-	2	-	2	-	2	-	1.9
Saturation pH at 20øC	na	units	-	9.62	-	9.65	-	9.62	-	9.62
Saturation pH at 4øC	na	units	-	10	-	10	-	10	-	10
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	3	0.5	0.4	0.6	0.4	0.5	0.4	0.5
Strontium	0.005	mg/L	0.117	0.009	0.009	0.009	0.009	0.009	0.009	0.009
Sulphate	2	mg/L	-	nd	-	nd	-	nd	-	nd
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	146	-	17	-	17	-	17	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-	nd
Total Suspended Solids	1	mg/L	-	1	-	nd	-	nd	-	nd
Turbidity	0.1	NTU	-	0.2	-	0.2	-	0.2	-	0.2
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.365	nd	0.004	nd	0.004	nd	0.004	nd
Fluoride	0.02	mg/L	-	nd	-	nd	-	nd	-	nd

Table A5.1: Water Quality at Myra Falls

Parameter Date Sampled >	LOQ	Units	MCR10-W Dissolved 97/09/13	MF1-W Total 97/09/12	MF1-W Dissolved 97/09/12	MF3-W Total 97/09/12	MF3-W Dissolved 97/09/12	MF7-W Total 97/09/12	MF7-W Dissolved 97/09/12	MN4-W Total 97/09/13
Acidity(as CaCO3)	1	mg/L	-	4	-	2	-	2	-	8
Alkalinity(as CaCO3)	1	mg/L	-	24	-	24	-	25	-	25
Aluminum	0.005	mg/L	0.025	0.013	0.009	0.013	0.02	0.017	0.009	0.019
Ammonia(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-	nd
Anion Sum	na	meq/L	-	0.608	-	0.604	-	0.625	-	0.7
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd	0.008
Beryllium	0.005	mg/L	nd	nd	nd	nd	-	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	24	-	24	-	25	-	25
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	0.018	nd	0.038	nd	0.02	nd	0.016
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd	0.00007
Calcium	0.1	mg/L	4.8	9.4	10.1	9.1	9.9	9.4	10.1	10.3
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	nd	-	nd	-	nd
Cation Sum	na	meq/L	-	0.588	-	0.573	-	0.613	-	0.653
Chloride	1	mg/L	-	nd	-	nd	-	nd	-	nd
Chromium	0.0005	mg/L	0.0007	nd	0.0005	nd	nd	nd	0.0006	nd
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Colour	5	TCU	-	nd	-	nd	-	nd	-	nd
Conductivity - @25øC	1	us/cm	-	55	-	53	-	56	-	59
Copper	0.0003	mg/L	0.0007	0.0009	0.001	0.0008	0.002	0.001	0.0013	0.0014
Dissolved Inorganic Carbon(as C)	0.2	mg/L	1.5	-	3.8	-	3.6	-	3.9	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	1	-	0.7	-	0.9	-	0.8	-
Hardness(as CaCO3)	0.1	mg/L	-	28.3	-	27.6	-	28.5	-	31
Ion Balance	0.01	%	-	1.62	-	2.63	-	0.94	-	3.46
Iron	0.02	mg/L	0.06	0.03	0.03	0.03	0.04	0.04	0.04	0.04
Langelier Index at 20øC	na	na	-	-1.36	-	-1.33	-	-1.35	-	-1.64
Langelier Index at 4øC	na	na	-	-1.76	-	-1.73	-	-1.75	-	-2.04
Lead	0.0001	mg/L	nd	nd	nd	nd	0.0012	nd	nd	nd
Magnesium	0.1	mg/L	0.2	0.7	0.8	0.7	0.7	0.7	0.8	0.7
Manganese	0.0005	mg/L	0.0006	0.002	nd	0.0016	0.001	0.0028	0.0008	0.0056
Mercury	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	-	0.08	-	0.07	-	0.07	-	0.07
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-	nd
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-	nd
pH	0.1	Units	-	7.7	-	7.7	-	7.7	-	7.3
Phosphorus, Dissolved	0.1	mg/L	nd	-	nd	-	nd	-	nd	-
Phosphorus, Total	0.01	mg/L	nd	nd	0.02	nd	0.01	nd	nd	nd
Potassium	0.5	mg/L	nd	nd	nd	0.5	nd	nd	0.8	nd
Reactive Silica(SiO2)	0.5	mg/L	-	3.1	-	3	-	3.1	-	2.8
Saturation pH at 20øC	na	units	-	9.04	-	9.05	-	9.02	-	8.97
Saturation pH at 4øC	na	units	-	9.44	-	9.45	-	9.42	-	9.37
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	0.00005	nd	nd	nd
Sodium	0.1	mg/L	0.5	0.7	0.5	0.7	0.5	0.7	0.5	0.7
Strontium	0.005	mg/L	0.009	0.014	0.014	0.014	0.014	0.014	0.013	0.018
Sulphate	2	mg/L	-	5	-	5	-	5	-	8
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	17	-	35	-	34	-	36	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-	nd
Total Suspended Solids	1	mg/L	-	nd	-	nd	-	1	-	nd
Turbidity	0.1	NTU	-	0.2	-	0.2	-	0.2	-	0.2
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.005	0.015	0.016	0.017	0.023	0.014	0.016	0.032
Fluoride	0.02	mg/L	-	nd	-	nd	-	nd	-	nd

Table A5.1: Water Quality at Myra Falls

Parameter Date Sampled >	LOQ	Units	MN4-W Dissolved 97/09/13	MN4S-W Total 97/09/13	MN4S-W Dissolved 97/09/13	MN7-W Total 97/09/13	MN7-W Total Replicate	MN7-W Dissolved 97/09/13	MN7-W Total field dup.	MN7-W Dissolved field dup
Acidity(as CaCO3)	1	mg/L	-	6	-	4	-	-	4	-
Alkalinity(as CaCO3)	1	mg/L	-	21	-	23	-	-	22	-
Aluminum	0.005	mg/L	0.023	0.017	0.021	0.02	0.02	0.013	0.018	0.014
Ammonia(as N)	0.05	mg/L	-	nd	-	nd	-	-	nd	-
Anion Sum	na	meq/L	-	0.552	-	0.655	-	-	0.622	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	0.008	nd	nd	0.007	0.007	0.007	0.006	0.007
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	21	-	23	-	-	22	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	0.009	nd	nd	-	nd	0.016	nd
Cadmium	0.00005	mg/L	0.00007	nd	nd	0.00007	0.00007	0.00006	0.00006	0.00006
Calcium	0.1	mg/L	11.2	8.6	9.1	9.8	-	10.9	10	10.6
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	nd	-	-	nd	-
Cation Sum	na	meq/L	-	0.527	-	0.626	-	-	0.619	-
Chloride	1	mg/L	-	nd	-	nd	-	-	nd	-
Chromium	0.0005	mg/L	0.0009	nd	0.0006	nd	nd	0.0007	nd	0.0007
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Colour	5	TCU	-	nd	-	nd	-	-	nd	-
Conductivity - @25øC	1	us/cm	-	55	-	61	-	-	59	-
Copper	0.0003	mg/L	0.0027	0.0009	0.0019	0.0014	0.0014	0.0034	0.0014	0.0019
Dissolved Inorganic Carbon(as C)	0.2	mg/L	4.2	-	3.5	-	-	4	-	3.8
Dissolved Organic Carbon(DOC)	0.5	mg/L	1.1	-	1.1	-	-	1.2	-	0.5
Hardness(as CaCO3)	0.1	mg/L	-	25.1	-	30	-	-	29.4	-
Ion Balance	0.01	%	-	2.27	-	2.23	-	-	0.28	-
Iron	0.02	mg/L	0.06	0.04	0.05	0.03	0.04	0.04	0.03	0.03
Langelier Index at 20øC	na	na	-	-1.39	-	-1.32	-	-	-1.25	-
Langelier Index at 4øC	na	na	-	-1.79	-	-1.72	-	-	-1.65	-
Lead	0.0001	mg/L	0.0005	nd	0.0005	nd	nd	nd	nd	nd
Magnesium	0.1	mg/L	0.7	0.6	0.6	0.6	-	0.7	0.7	0.7
Manganese	0.0005	mg/L	0.0025	0.004	0.0012	0.0046	0.0045	0.0012	0.004	0.0009
Mercury	0.0001	mg/L	nd	nd	nd	nd	-	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0004	0.0003	0.0003	0.0004	0.0003	0.0003	0.0003	0.0005
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	-	nd	-	-	0.07	-	0.06	-
Nitrite(as N)	0.01	mg/L	-	nd	-	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	-	nd	-	nd	-
pH	0.1	Units	-	7.8	-	-	7.7	-	7.8	-
Phosphorus, Dissolved	0.1	mg/L	nd	-	nd	-	-	nd	-	nd
Phosphorus, Total	0.01	mg/L	0.02	nd	nd	nd	-	nd	nd	nd
Potassium	0.5	mg/L	nd	nd	nd	nd	-	nd	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	-	2.1	-	2.8	-	-	2.8	-
Saturation pH at 20øC	na	units	-	9.14	-	9.02	-	-	9.05	-
Saturation pH at 4øC	na	units	-	9.54	-	9.42	-	-	9.45	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	0.00012	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	0.7	0.6	0.5	0.7	-	0.6	0.8	0.6
Strontium	0.005	mg/L	0.017	0.014	0.014	0.017	0.017	0.017	0.016	0.016
Sulphate	2	mg/L	-	6	-	8	-	-	8	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	40	-	31	-	-	38	-	37
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	nd	-	nd	-	-	nd	-
Total Suspended Solids	1	mg/L	-	nd	-	nd	-	-	nd	-
Turbidity	0.1	NTU	-	0.3	-	0.2	-	-	0.2	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.035	0.016	0.02	0.031	0.031	0.033	0.028	0.079
Fluoride	0.02	mg/L	-	nd	-	nd	-	-	nd	-

Table A5.1: Water Quality at Myra Falls

Parameter Date Sampled >	LOQ	Units	MN10-W Total 97/09/13	MN10-W Dissolved 97/09/13	MR1-W Total 97/09/12	MR1-W Total Replicate	MR1-W Dissolved 97/09/12	MR1-W Dissolved Replicate	MR3-W Total 97/09/12	MR3-W Dissolved 97/09/12
Acidity(as CaCO3)	1	mg/L	4	-	6	6	-	-	6	-
Alkalinity(as CaCO3)	1	mg/L	23	-	10	10	-	-	11	-
Aluminum	0.005	mg/L	0.017	0.013	0.062	-	0.054	0.055	0.065	0.053
Ammonia(as N)	0.05	mg/L	nd	-	nd	nd	-	-	nd	-
Anion Sum	na	meq/L	0.613	-	0.236	-	-	-	0.262	-
Antimony	0.0005	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Barium	0.005	mg/L	0.005	0.005	nd	-	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	23	-	-	9	-	-	11	-
Bismuth	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	0.011	0.01	nd	nd	0.074	nd
Cadmium	0.00005	mg/L	0.00007	0.00006	nd	-	nd	nd	nd	nd
Calcium	0.1	mg/L	9.5	10.3	3.3	3.2	3.4	3.4	3.1	3.3
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	-	-	nd	-
Cation Sum	na	meq/L	0.602	-	0.251	-	-	-	0.249	-
Chloride	1	mg/L	nd	-	nd	nd	-	-	nd	-
Chromium	0.0005	mg/L	nd	0.0005	nd	-	nd	nd	nd	0.0006
Cobalt	0.0002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Colour	5	TCU	nd	-	20	20	-	-	20	-
Conductivity - @25øC	1	us/cm	56	-	26	27	-	-	25	-
Copper	0.0003	mg/L	0.0012	0.0033	0.0011	-	0.0016	0.0016	0.001	0.0016
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	3.6	-	-	1.4	1.4	-	0.9
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	1	-	-	5.4	5.7	-	3.6
Hardness(as CaCO3)	0.1	mg/L	28.7	-	10.9	-	-	-	10.9	-
Ion Balance	0.01	%	0.88	-	3.15	-	-	-	2.6	-
Iron	0.02	mg/L	0.03	0.03	0.04	-	0.02	0.02	0.04	0.04
Langelier Index at 20øC	na	na	-1.23	-	-2.91	-	-	-	-2.74	-
Langelier Index at 4øC	na	na	-1.63	-	-3.31	-	-	-	-3.14	-
Lead	0.0001	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Magnesium	0.1	mg/L	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6
Manganese	0.0005	mg/L	0.0031	0.0006	0.0011	-	0.0005	0.0005	0.0012	0.0006
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0003	0.0003	nd	-	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	0.05	-	0.11	0.11	-	-	0.06	-
Nitrite(as N)	0.01	mg/L	nd	-	nd	nd	-	-	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	nd	-	-	nd	-
pH	0.1	Units	7.8	-	7	7.3	-	-	7.1	-
Phosphorus, Dissolved	0.1	mg/L	-	nd	-	-	nd	nd	-	nd
Phosphorus, Total	0.01	mg/L	nd	nd	nd	nd	0.01	0.01	nd	0.01
Potassium	0.5	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	2.8	-	4.6	4.6	-	-	4.7	-
Saturation pH at 20øC	na	units	9.04	-	9.91	-	-	-	9.85	-
Saturation pH at 4øC	na	units	9.44	-	10.3	-	-	-	10.3	-
Selenium	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Sodium	0.1	mg/L	0.6	0.6	0.8	0.7	0.7	0.7	1	0.7
Strontium	0.005	mg/L	0.015	0.015	0.006	-	0.006	0.006	0.006	0.006
Sulphate	2	mg/L	6	-	nd	nd	-	-	nd	-
Thallium	0.0001	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	36	-	-	17	-	-	18
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	-	0.07	0.09	-	-	0.06	-
Total Suspended Solids	1	mg/L	nd	-	nd	nd	-	-	nd	-
Turbidity	0.1	NTU	0.2	-	0.2	0.2	-	-	0.2	-
Uranium	0.0001	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	-	nd	nd	nd	nd
Zinc	0.001	mg/L	0.023	0.025	0.002	-	0.004	0.005	nd	0.006
Fluoride	0.02	mg/L	nd	-	nd	nd	-	-	nd	-

Table A5.1: Water Quality at Myra Falls

Parameter	LOQ	Units	MR7-W Total	MR7-W Dissolved
Date Sampled >			97/09/12	97/09/12
Acidity(as CaCO3)	1	mg/L	8	-
Alkalinity(as CaCO3)	1	mg/L	10	-
Aluminum	0.005	mg/L	0.06	0.054
Ammonia(as N)	0.05	mg/L	nd	-
Anion Sum	na	meq/L	0.239	-
Antimony	0.0005	mg/L	nd	nd
Arsenic	0.002	mg/L	nd	nd
Barium	0.005	mg/L	nd	nd
Beryllium	0.005	mg/L	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	10	-
Bismuth	0.002	mg/L	nd	nd
Boron	0.005	mg/L	0.014	nd
Cadmium	0.00005	mg/L	nd	nd
Calcium	0.1	mg/L	3.1	3.3
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-
Cation Sum	na	meq/L	0.252	-
Chloride	1	mg/L	nd	-
Chromium	0.0005	mg/L	nd	0.0006
Cobalt	0.0002	mg/L	nd	nd
Colour	5	TCU	20	-
Conductivity - @25øC	1	us/cm	25	-
Copper	0.0003	mg/L	0.0009	0.0021
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	1.5
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	2.7
Hardness(as CaCO3)	0.1	mg/L	10.8	-
Ion Balance	0.01	%	2.56	-
Iron	0.02	mg/L	0.03	0.03
Langelier Index at 20øC	na	na	-2.69	-
Langelier Index at 4øC	na	na	-3.09	-
Lead	0.0001	mg/L	nd	nd
Magnesium	0.1	mg/L	0.6	0.6
Manganese	0.0005	mg/L	0.001	nd
Mercury	0.0001	mg/L	nd	nd
Molybdenum	0.0001	mg/L	nd	nd
Nickel	0.001	mg/L	nd	nd
Nitrate(as N)	0.05	mg/L	0.06	-
Nitrite(as N)	0.01	mg/L	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-
pH	0.1	Units	7.2	-
Phosphorus, Dissolved	0.1	mg/L	-	nd
Phosphorus, Total	0.01	mg/L	nd	0.01
Potassium	0.5	mg/L	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	4.7	-
Saturation pH at 20øC	na	units	9.9	-
Saturation pH at 4øC	na	units	10.3	-
Selenium	0.002	mg/L	nd	nd
Silver	0.00005	mg/L	nd	nd
Sodium	0.1	mg/L	0.8	0.7
Strontium	0.005	mg/L	0.006	0.006
Sulphate	2	mg/L	nd	-
Thallium	0.0001	mg/L	nd	nd
Tin	0.002	mg/L	nd	nd
Titanium	0.002	mg/L	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	17
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.06	-
Total Suspended Solids	1	mg/L	nd	-
Turbidity	0.1	NTU	0.2	-
Uranium	0.0001	mg/L	nd	nd
Vanadium	0.002	mg/L	nd	nd
Zinc	0.001	mg/L	nd	0.005
Fluoride	0.02	mg/L	nd	-

Table A5.2: Total Metals in Sediment Samples from Myra Falls

Component	MDL	Units	MF1-S	MF2-S	MF3-S	MF3-S	MF4-S	MF5-S
Client ID:			MF1-S	MF2-S	MF3-S	MF3-S	MF4-S	MF5-S
Date Sampled:			97/09/06	97/09/07	97/09/07	97/09/07	97/09/08	97/09/08
						Duplicate		
ICP/MS - HNO3-H2O2								
Aluminum	1	mg/kg	30000	28000	27000	27000	34000	24000
Antimony	0.2	"	<	<	0.3	0.2	0.6	<
Arsenic	0.5	"	22	15	9.6	8.8	15	14
Barium	0.5	"	140	97	110	100	97	86
Beryllium	0.2	"	0.4	0.4	0.3	0.3	0.4	0.3
Bismuth	0.5	"	<	<	<	<	<	<
Boron	2.5	"	<	<	5.1	<	<	<
Cadmium	0.05	"	1.1	3.1	2.3	2.3	0.86	1.1
Chromium	0.6	"	53	49	42	41	47	39
Cobalt	0.2	"	36	35	28	28	33	26
Copper	0.2	"	190	310	250	240	180	140
Iron	20	"	57000	53000	41000	41000	49000	41000
Lead	0.1	"	18	70	51	50	14	14
Manganese	1	"	2500	5000	1200	1200	1400	1600
Molybdenum	0.2	"	1.8	2.6	1.7	1.6	1.4	1.9
Nickel	0.5	"	47	43	41	40	50	37
Selenium	1	"	1.7	2.1	2	1.4	1.6	1.1
Silver	0.05	"	0.34	0.64	0.48	0.47	0.3	0.33
Strontium	0.5	"	28	30	37	41	46	41
Thallium	0.2	"	<	<	<	<	<	<
Tin	0.2	"	0.8	0.7	1	1.1	0.9	0.7
Titanium	0.3	"	3000	2500	2700	2600	4600	2600
Vanadium	1	"	180	160	160	160	200	140
Zinc	1	"	240	630	430	410	220	170
Calcium	20	mg/kg	21452.5	20690	23132.5	24445	28725	22837.5
Magnesium	20	"	19220	18417.5	17427.5	18467.5	20550	18450
pH (20 DEG C)			6.2	6.48	6.07	-	6.44	6.37
Loss on Ignition	0.1	(%)	17	17	17	-	12	12
Coarse Gravel (>4.8mm)	0.1	%	<	<	<	-	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	3.5	3.8	1.6	-	0.2	0.7
V. Coarse Sand (1.0-2.0mm)	0.1	"	1.8	1.2	1.8	-	0.4	0.2
Coarse Sand (0.50-1.0mm)	0.1	"	12	5.3	4.5	-	2.7	1.5
Med. Sand (0.25-0.50mm)	0.1	"	8	9.3	3.9	-	5.3	3.1
Fine Sand (0.10-0.25mm)	0.1	"	4.6	8.3	4	-	4.7	6.5
V. Fine Sand (0.050-0.10mm	0.1	"	3.6	6.7	23	-	7.2	13
Silt (0.002-0.050mm)	0.1	"	54	51	49	-	70	66
Clay (<0.002mm)	0.1	"	12	15	12	-	9.8	9.6
V. Fine Sand, Silt, Clay (<0.10mm) **								
Mercury	0.04	mg/kg	0.11	0.18	0.12	0.12	0.09	0.11
TOC (Solid)	0.1	(%)	4.2	5.5	5.5	-	3.4	4.2
Bulk Density		g/ml	0.22	0.22	0.34		0.33	0.28
Moisture Content		%	80	80.5	71.5		71.9	75.6
Munsell Number			5Y 4/3	2.5Y 3/3	5Y 2.5/2		2.5Y 4/3	2.5Y 4/3
Munsell Colour			Olive	Dark olive brown	Black		Olive brown	Olive brown

Table A5.2: Total Metals in Sediment Samples from Myra Falls

Component	*Client ID:* / *Date Sampled:* MDL	Units	MF6-S 97/09/08	MN10-S 97/09/11	MF7-S 97/09/08	MN4-S 97/09/09	MN5-S 97/09/10	MN5-S 97/09/10 Duplicate
ICP/MS - HNO3-H2O2								
Aluminum	1	mg/kg	25000	20000	25000	22000	14000	-
Antimony	0.2	"	<	0.5	<	13	1.8	-
Arsenic	0.5	"	32	59	10	73	59	-
Barium	0.5	"	170	1400	170	1200	140	-
Beryllium	0.2	"	0.3	0.4	0.3	0.4	0.3	-
Bismuth	0.5	"	<	2.3	<	2.4	3.4	-
Boron	2.5	"	<	<	<	<	<	-
Cadmium	0.05	"	2.1	9.9	1.4	12	13	-
Chromium	0.6	"	44	39	47	47	33	-
Cobalt	0.2	"	32	25	28	22	14	-
Copper	0.2	"	220	800	160	1100	1000	-
Iron	20	"	55000	47000	41000	50000	38000	-
Lead	0.1	"	50	430	26	760	650	-
Manganese	1	"	7800	9100	1600	1600	1600	-
Molybdenum	0.2	"	2.6	17	1.6	23	36	-
Nickel	0.5	"	40	29	40	30	21	-
Selenium	1	"	1.6	1.4	1.8	2.8	2	-
Silver	0.05	"	0.54	7	0.42	11	15	-
Strontium	0.5	"	34	44	30	37	31	-
Thallium	0.2	"	<	<	<	0.2	0.2	-
Tin	0.2	"	0.6	0.9	1	0.9	0.6	-
Titanium	0.3	"	2700	1100	2300	840	340	-
Vanadium	1	"	160	100	150	93	54	-
Zinc	1	"	390	1600	240	3000	2200	-
Calcium	20	mg/kg	21482.5	12530	19277.5	7682.5	6070	-
Magnesium	20	"	17970	19697.5	18720	16802.5	15487.5	-
pH (20 DEG C)			6.6	6.58	6.85	6.48	6.23	6.28
Loss on Ignition	0.1	(%)	13	12	13	7.3	6.8	-
Coarse Gravel (>4.8mm)	0.1	%	<	<	<	<	<	-
Fine Gravel (2.0-4.8mm)	0.1	"	1.2	2.3	1.1	0.1	0.2	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.7	2.9	1.8	0.2	0.4	-
Coarse Sand (0.50-1.0mm)	0.1	"	4	7.4	3.3	3.8	4.4	-
Med. Sand (0.25-0.50mm)	0.1	"	4.8	5.8	4.5	4.6	4.1	-
Fine Sand (0.10-0.25mm)	0.1	"	11	5.3	4.6	5.2	5.5	-
V. Fine Sand (0.050-0.10mm)	0.1	"	7.2	5.8	3.3	16	12	-
Silt (0.002-0.050mm)	0.1	"	55	49	55	54	51	-
Clay (<0.002mm)	0.1	"	16	22	26	17	23	-
V. Fine Sand, Silt, Clay (<0.10mm) **								
Mercury	0.04	mg/kg	0.14	0.25	0.31	0.3	0.29	-
TOC (Solid)	0.1	(%)	4.2	3.4	2.8	2.2	2	-
Bulk Density		g/ml	0.27	0.31	0.24	0.43	0.46	
Moisture Content		%	77.1	74.7	78.6	66.9	64.3	
Munsell Number			5Y 3/2	2.5Y 5/3	5Y 4/3	5Y 4/3	5Y 4/3	
Munsell Colour			Dark olive grey	Light olive brown	Olive	Olive	Olive	

Table A5.2: Total Metals in Sediment Samples from Myra Falls

Component	MDL	Units	MN6-S	MN7-S	MN8-S	MN9-S	MN9-S
Client ID:			MN6-S	MN7-S	MN8-S	MN9-S	MN9-S
Date Sampled:			97/09/10	97/09/10	97/09/11	97/09/11	97/09/11 Duplicate
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	23000	21000	23000	22000	20000
Antimony	0.2	"	0.9	1	0.8	1.1	1.2
Arsenic	0.5	"	60	83	89	53	50
Barium	0.5	"	1200	1100	1400	700	680
Beryllium	0.2	"	0.5	0.4	0.5	0.4	0.4
Bismuth	0.5	"	3.1	3.9	3.2	2.9	3.1
Boron	2.5	"	<	<	3.1	<	<
Cadmium	0.05	"	7.8	10	9.5	9.7	10
Chromium	0.6	"	48	46	49	44	41
Cobalt	0.2	"	25	23	26	23	22
Copper	0.2	"	1300	1400	1500	1200	1100
Iron	20	"	52000	50000	58000	43000	40000
Lead	0.1	"	760	890	920	700	660
Manganese	1	"	3000	7900	10000	2000	1900
Molybdenum	0.2	"	23	31	26	20	21
Nickel	0.5	"	33	29	32	29	27
Selenium	1	"	2.1	2.1	1.9	2.2	1.7
Silver	0.05	"	11	12	11	8.9	9.6
Strontium	0.5	"	43	41	40	27	29
Thallium	0.2	"	<	<	<	<	<
Tin	0.2	"	0.8	0.7	0.6	0.6	0.7
Titanium	0.3	"	940	730	830	850	820
Vanadium	1	"	100	88	100	100	93
Zinc	1	"	1900	2400	2600	2300	2100
Calcium	20	mg/kg	10257.5	8230	9057.5	9730	9522.5
Magnesium	20	"	19505	17920	18372.5	17227.5	17132.5
pH (20 DEG C)			6.6	6.34	6.85	6.55	-
Loss on Ignition	0.1	(%)	10	9.7	13	12	-
Coarse Gravel (>4.8mm)	0.1	%	<	<	<	<	-
Fine Gravel (2.0-4.8mm)	0.1	"	0.7	0.6	2.2	0.8	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	1.3	1.2	2.2	0.6	-
Coarse Sand (0.50-1.0mm)	0.1	"	6.8	3.6	2.1	2.1	-
Med. Sand (0.25-0.50mm)	0.1	"	6.5	7.2	2.9	3.8	-
Fine Sand (0.10-0.25mm)	0.1	"	8.3	13	4.6	8.4	-
V. Fine Sand (0.050-0.10mm)	0.1	"	3.4	7.5	6.4	13	-
Silt (0.002-0.050mm)	0.1	"	47	59	55	51	-
Clay (<0.002mm)	0.1	"	26	7.2	25	20	-
V. Fine Sand, Silt, Clay (<0.10mm) **							
Mercury	0.04	mg/kg	0.3	0.12	0.32	0.3	0.3
TOC (Solid)	0.1	(%)	2.4	3.4	2.4	3.3	-
Bulk Density		g/ml	0.37	0.36	0.35	0.31	
Moisture Content		%	70.2	70.3	71	74.2	
Munsell Number			2.5Y 5/3	2.5Y 4/3	2.5Y 4/4	5Y 3/2	
Munsell Colour			Light olive brown	Olive brown	Olive brown	Dark olive grey	

Table A5.2: Total Metals in Sediment Samples from Myra Falls

Component	MDL	Units	mr1-s 97/09/04	mr1-s 97/09/04 Duplicate	mr2-s 97/09/04	mr3-s 97/09/04	mr4-s 97/09/05
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	20000	20000	18000	19000	18000
Antimony	0.2	"	0.2	0.2	0.2	<	<
Arsenic	0.5	"	13	13	14	13	13
Barium	0.5	"	78	79	90	73	130
Beryllium	0.2	"	0.3	0.3	0.3	0.3	0.3
Bismuth	0.5	"	<	<	<	<	<
Boron	2.5	"	<	<	<	<	<
Cadmium	0.05	"	0.35	0.4	0.35	0.34	0.39
Chromium	0.6	"	36	38	35	36	32
Cobalt	0.2	"	23	23	24	22	25
Copper	0.2	"	76	76	72	75	76
Iron	20	"	33000	34000	44000	35000	53000
Lead	0.1	"	40	40	42	44	49
Manganese	1	"	19000	20000	23000	15000	28000
Molybdenum	0.2	"	1	0.9	1	0.9	1.2
Nickel	0.5	"	19	20	19	20	20
Selenium	1	"	2	2.1	2.1	1.9	1.4
Silver	0.05	"	0.25	0.25	0.24	0.27	0.29
Strontium	0.5	"	18	18	20	20	28
Thallium	0.2	"	<	<	<	<	<
Tin	0.2	"	1.1	1.1	3	1	0.8
Titanium	0.3	"	720	700	710	740	1200
Vanadium	1	"	100	100	96	97	95
Zinc	1	"	59	61	59	61	63
Calcium	20	mg/kg	10067.5	9802.5	9732.5	11025	10260
Magnesium	20	"	6852.5	6827.5	6960	7872.5	7102.5
pH (20 DEG C)			5.8	-	5.66	5.68	5.75
Loss on Ignition	0.1	(%)	17	16	16	16	16
Coarse Gravel (>4.8mm)	0.1	%	<	-	<	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	<	-	0.1	<	0.2
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.4	-	3.8	0.4	3.2
Coarse Sand (0.50-1.0mm)	0.1	"	28	-	30	25	24
Med. Sand (0.25-0.50mm)	0.1	"	22	-	31	19	20
Fine Sand (0.10-0.25mm)	0.1	"	13	-	17	19	16
V. Fine Sand (0.050-0.10mm)	0.1	"					
Silt (0.002-0.050mm)	0.1	"					
Clay (<0.002mm)	0.1	"					
V. Fine Sand, Silt, Clay (<0.10mm) **			37	-	18	36	38
Mercury	0.04	mg/kg	0.3	-	0.28	0.29	0.3
TOC (Solid)	0.1	(%)	6.2	-	6.3	6.5	6
Bulk Density		g/ml	0.16		0.17	0.17	0.17
Moisture Content		%	85.1		84.1	84.8	84.6
Munsell Number			10YR 2/2		10YR 2/2	10YR 2/2	10YR 2/2
Munsell Colour			Very dark brown		Very dark brown	Very dark brown	Very dark brown

Table A5.2: Total Metals in Sediment Samples from Myra Falls

Component	MDL	Units	mr5-s	mr6-s	mr7-s
Client ID:			mr5-s	mr6-s	mr7-s
Date Sampled:			97/09/05	97/09/05	97/09/05
ICP/MS - HNO3-H2O2					
Aluminum	1	mg/kg	18000	19000	19000
Antimony	0.2	"	0.2	0.2	<
Arsenic	0.5	"	13	13	21
Barium	0.5	"	90	91	140
Beryllium	0.2	"	0.3	0.2	0.3
Bismuth	0.5	"	<	<	<
Boron	2.5	"	<	<	<
Cadmium	0.05	"	0.4	0.39	0.42
Chromium	0.6	"	32	34	35
Cobalt	0.2	"	24	25	31
Copper	0.2	"	75	79	87
Iron	20	"	39000	41000	63000
Lead	0.1	"	53	53	49
Manganese	1	"	26000	26000	36000
Molybdenum	0.2	"	1.3	1.2	1.6
Nickel	0.5	"	20	21	26
Selenium	1	"	1.4	1.4	1.2
Silver	0.05	"	0.29	0.29	0.25
Strontium	0.5	"	27	26	27
Thallium	0.2	"	<	<	<
Tin	0.2	"	1	1.1	1.8
Titanium	0.3	"	790	810	980
Vanadium	1	"	92	98	100
Zinc	1	"	58	61	69
Calcium	20	mg/kg	11180	11495	12467.5
Magnesium	20	"	7977.5	8227.5	8847.5
pH (20 DEG C)			5.46	6.03	5.57
Loss on Ignition	0.1	(%)	16	16	15
Coarse Gravel (>4.8mm)	0.1	%	<	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	0.3	1.4	0.2
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.8	3.6	0.6
Coarse Sand (0.50-1.0mm)	0.1	"	43	39	25
Med. Sand (0.25-0.50mm)	0.1	"	26	26	29
Fine Sand (0.10-0.25mm)	0.1	"	10	11	23
V. Fine Sand (0.050-0.10mm	0.1	"			
Silt (0.002-0.050mm)	0.1	"			
Clay (<0.002mm)	0.1	"			
V. Fine Sand, Silt, Clay (<0.10mm) **			20	19	23
Mercury	0.04	mg/kg	0.33	0.28	0.31
TOC (Solid)	0.1	(%)	6.2	5.9	5.7
Bulk Density		g/ml	0.18	0.18	0.17
Moisture Content		%	83.9	83.3	84.6
Munsell Number			10YR 2/2	10YR 2/2	10YR 2/2
Munsell Colour			Very dark brown	Very dark brown	Very dark brown

Table A5.3: Results of Partial Extraction Analysis on Samples from Myra Falls

Component	*Client ID:* *Date Sampled:* MDL	Units	MF1-S 97/09/06	MF2-S 97/09/07	MF3-S 97/09/07	MF3-S 97/09/07 Duplicate	MF4-S 97/09/08
Aluminum (ext.)	1	mg/kg	1800	2100	1600	1500	2000
Antimony (ext.)	0.2	"	<	<	<	<	<
Arsenic (ext.)	0.5	"	<	<	<	<	<
Barium (ext.)	0.5	"	37	53	31	31	28
Beryllium (ext.)	0.2	"	<	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<	<
Boron (ext.)	2.5	"	<	<	<	<	<
Cadmium (ext.)	0.05	"	0.36	1.3	0.56	0.51	0.32
Chromium (ext.)	0.6	"	6.1	6.7	4.5	4.4	5.6
Cobalt (ext.)	0.2	"	5.9	8.1	4.1	4.1	4.8
Copper (ext.)	0.2	"	7.3	17	2.4	2.4	12
Iron (ext.)	20	"	5400	6800	4200	4100	3900
Lead (ext.)	0.1	"	1.4	9.5	5.4	5.4	1
Manganese (ext.)	1	"	1000	2500	460	460	450
Molybdenum (ext.)	0.2	"	<	<	<	<	<
Nickel (ext.)	0.5	"	2.5	2.8	1.9	1.9	2.4
Selenium (ext.)	1	"	<	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<	<
Strontium (ext.)	0.5	"	3.4	4	4.9	4.9	3.6
Thallium (ext.)	0.2	"	<	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<	<
Titanium (ext.)	0.3	"	1.1	1.1	0.9	0.9	1.3
Vanadium (ext.)	1	"	16	17	18	18	18
Zinc (ext.)	1	"	65	240	140	140	49
Calcium	20	mg/kg	3782	4042	3716	3710	3546
Magnesium	20	"	408	410	528	512	493

Table A5.3: Results of Partial Extraction Analysis on Samples from Myra Falls

Component	*Client ID:* / *Date Sampled:* / MDL	Units	MF5-S 97/09/08	MF6-S 97/09/08	MF7-S 97/09/08	MN4-S 97/09/09	MN5-S 97/09/10
Aluminum (ext.)	1	mg/kg	2000	1900	2000	1600	1700
Antimony (ext.)	0.2	"	<	<	0.3	0.2	0.5
Arsenic (ext.)	0.5	"	<	<	<	<	<
Barium (ext.)	0.5	"	34	54	100	84	82
Beryllium (ext.)	0.2	"	<	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	0.6	<	0.5
Boron (ext.)	2.5	"	<	<	<	<	<
Cadmium (ext.)	0.05	"	0.34	0.75	3.1	2.6	2.4
Chromium (ext.)	0.6	"	6.3	6.4	5.6	4.4	4.6
Cobalt (ext.)	0.2	"	5.3	7.2	4.1	3.7	3.2
Copper (ext.)	0.2	"	15	10	36	25	42
Iron (ext.)	20	"	6600	6600	7800	5100	6600
Lead (ext.)	0.1	"	0.9	5.1	350	230	270
Manganese (ext.)	1	"	790	4100	1000	560	820
Molybdenum (ext.)	0.2	"	<	<	<	0.2	0.2
Nickel (ext.)	0.5	"	2.6	2.6	2.8	2	2.2
Selenium (ext.)	1	"	<	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<	<
Strontium (ext.)	0.5	"	3.4	3.1	2.5	2.5	2
Thallium (ext.)	0.2	"	<	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<	<
Titanium (ext.)	0.3	"	1.2	1	0.8	0.8	0.8
Vanadium (ext.)	1	"	18	17	7.6	8.5	6.6
Zinc (ext.)	1	"	53	140	1100	750	810
Calcium	20	mg/kg	3388	2864	1806	1988	1438
Magnesium	20	"	433	354	424	364	347

Table A5.3: Results of Partial Extraction Analysis on Samples from Myra Falls

Component	*Client ID:* *Date Sampled:* MDL	Units	MN6-S 97/09/10	MN7-S 97/09/10	MN8-S 97/09/11	MN9-S 97/09/11	MN9-S 97/09/11 Duplicate
Aluminum (ext.)	1	mg/kg	2100	2000	2000	2100	2200
Antimony (ext.)	0.2	"	0.3	0.3	0.2	<	<
Arsenic (ext.)	0.5	"	<	<	<	<	<
Barium (ext.)	0.5	"	110	130	150	160	170
Beryllium (ext.)	0.2	"	<	<	<	0.2	0.2
Bismuth (ext.)	0.5	"	0.5	0.5	<	<	<
Boron (ext.)	2.5	"	<	<	<	<	<
Cadmium (ext.)	0.05	"	2.3	3.1	3	2.3	2.2
Chromium (ext.)	0.6	"	5.4	5.2	5.3	4.9	5.3
Cobalt (ext.)	0.2	"	4.9	5.1	5.4	4.4	4.6
Copper (ext.)	0.2	"	51	61	80	6.3	6
Iron (ext.)	20	"	7300	7700	8100	5600	5800
Lead (ext.)	0.1	"	230	270	240	220	210
Manganese (ext.)	1	"	1300	3700	4100	820	880
Molybdenum (ext.)	0.2	"	<	0.2	0.2	<	<
Nickel (ext.)	0.5	"	2.6	2.7	2.7	2.2	2.4
Selenium (ext.)	1	"	<	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<	<
Strontium (ext.)	0.5	"	2.4	2.2	2.3	3.2	3.1
Thallium (ext.)	0.2	"	<	<	<	<	<
Tin (ext.)	0.2	"	<	<	<0.5	<0.5	<0.5
Titanium (ext.)	0.3	"	1.1	1	1	1	1
Vanadium (ext.)	1	"	9.4	8.3	8.4	11	11
Zinc (ext.)	1	"	750	910	880	790	830
Calcium	20	mg/kg	1737	1633	1673	2128	2130
Magnesium	20	"	293	268	257	348	343

Table A5.3: Results of Partial Extraction Analysis on Samples from Myra Falls

Component	MDL	Units	MN10-S	MR1-S	MR1-S	MR2-S	MR3-S
	Client ID:		MN10-S	MR1-S	MR1-S	MR2-S	MR3-S
	Date Sampled:		97/09/11	97/09/04	97/09/04	97/09/04	97/09/04
					Duplicate		
Aluminum (ext.)	1	mg/kg	1800	2900	2900	2500	2700
Antimony (ext.)	0.2	"	0.3	0.2	<	0.2	<
Arsenic (ext.)	0.5	"	<	<	<	<	<
Barium (ext.)	0.5	"	180	22	22	24	22
Beryllium (ext.)	0.2	"	<	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<	<
Boron (ext.)	2.5	"	<	<	<	<	<
Cadmium (ext.)	0.05	"	3.8	0.14	0.14	0.13	0.13
Chromium (ext.)	0.6	"	5.2	7.2	7.3	6.4	6.5
Cobalt (ext.)	0.2	"	5.8	5.9	6	5.5	6
Copper (ext.)	0.2	"	63	3.8	3.7	3.9	3.5
Iron (ext.)	20	"	6400	4800	4700	5500	4800
Lead (ext.)	0.1	"	120	6	6.1	5.5	6.2
Manganese (ext.)	1	"	4500	8500	8400	9100	7100
Molybdenum (ext.)	0.2	"	<	<	<	<	<
Nickel (ext.)	0.5	"	2.4	1.6	1.6	1.3	1.5
Selenium (ext.)	1	"	<	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<	<
Strontium (ext.)	0.5	"	3.9	4	4	3.9	3.9
Thallium (ext.)	0.2	"	<	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<	<
Titanium (ext.)	0.3	"	0.9	1.3	1.2	1	1.2
Vanadium (ext.)	1	"	8.6	14	14	11	12
Zinc (ext.)	1	"	630	11	11	9.9	11
Calcium	20	mg/kg	2156	2288	2296	2010	2160
Magnesium	20	"	254	216	212	198	217

Table A5.3: Results of Partial Extraction Analysis on Samples from Myra Falls

Component	MDL	Units	MR5-S	MR6-S	MR7-S	MR4-S
Client ID:			MR5-S	MR6-S	MR7-S	MR4-S
Date Sampled:			97/09/04	97/09/04	97/09/04	97/09/05
Aluminum (ext.)	1	mg/kg	3000	2200	2200	2300
Antimony (ext.)	0.2	"	<	<	<	<
Arsenic (ext.)	0.5	"	<	<	<	<
Barium (ext.)	0.5	"	29	37	42	36
Beryllium (ext.)	0.2	"	<	<	<	0.5
Bismuth (ext.)	0.5	"	<	<	<	<
Boron (ext.)	2.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.14	0.16	0.17	0.14
Chromium (ext.)	0.6	"	7.1	5.9	5.7	6.2
Cobalt (ext.)	0.2	"	6.8	8.3	6.7	6.2
Copper (ext.)	0.2	"	5.3	4.8	6.1	4.2
Iron (ext.)	20	"	6200	10000	8700	6800
Lead (ext.)	0.1	"	7.7	5.1	5.8	5.3
Manganese (ext.)	1	"	13000	12000	15000	13000
Molybdenum (ext.)	0.2	"	<	<	<	<
Nickel (ext.)	0.5	"	1.7	1.8	2.5	1.5
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	5.8	5.1	6.2	5.9
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	1.2	0.7	0.9	0.7
Vanadium (ext.)	1	"	12	8.6	8.7	8.9
Zinc (ext.)	1	"	14	11	12	11
Calcium	20	mg/kg	2406	2206	2214	2194
Magnesium	20	"	205	190	183	166

Table A5.4: Results of AVS/SEM Analysis Conducted on Samples from Myra Falls

Component	MDL	MR1-S 97/09/04 umol/g	MR2-S 97/09/04 umol/g	MR3-S 97/09/04 umol/g	MR4-S 97/09/04 umol/g	MR5-S 97/09/04 umol/g	MR6-S 97/09/04 umol/g
Aluminum	2	985.8	1157.1	703.6	932.9	1354.4	485.3
Barium	0.1	1.1	1.2	0.7	1.7	1.8	1.0
Beryllium	0.1	<	<	<	<	<	<
Boron	1	2.3	2.1	<	2.9	3.4	<
Cadmium	0.05	<	<	<	<	<	<
Calcium	7	146.0	176.5	108.3	183.6	249.2	100.7
Chromium	0.1	0.2	0.3	0.2	<	0.3	0.1
Cobalt	0.2	0.5	0.5	0.3	0.5	0.9	0.4
Copper	0.1	1.5	1.7	1.0	1.6	2.2	0.9
Iron	0.2	2128.9	1044.3	461.7	1006.2	1920.9	860.4
Lead	0.4	0.3	0.4	0.3	0.4	0.6	0.2
Magnesium	3	59.8	92.6	55.3	63.9	117.4	44.5
Manganese	0.1	645.9	758.2	321.1	952.2	1198.1	477.0
Molybdenum	0.1	<	<	<	<	<	<
Nickel	0.2	0.3	<	0.3	<	0.5	<
Potassium	10	<	<	<	<	<	<
Silver	0.1	<	<	<	<	<	<
Sodium	6	<	10.9	8.8	17.7	21.2	6.6
Strontium	0.1	0.3	0.4	0.2	0.5	0.6	0.2
Sulphur	3	10.5	11.7	7.2	19.9	14.4	5.8
Thallium	0.5	<	<	<	<	<	<
Tin	0.5	<	<	<	<	<	<
Titanium	0.3	7.8	9.6	6.2	7.7	12.7	4.8
Vanadium	0.1	1.5	1.9	1.3	1.2	2.1	0.8
Zinc	0.1	1.1	1.5	0.8	1.1	1.6	0.6
Zirconium	0.5	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		3.1	3.6	2.4	3.0	4.8	1.7
AV Sulphide	0.1	15.5	116.0	43.0	2.0	5.0	1.7
SEM/AVS Ratio		0.20	0.03	0.06	1.52	0.97	1.00

Table A5.4: Results of AVS/SEM Analysis Conducted on Samples from Myra Falls

Component	MDL	MR7-S 97/09/04 umol/g	MF1-S umol/g	MF2-S umol/g	MF2-S umol/g Duplicate	MF3-S umol/g	MF3-S umol/g Duplicate
Aluminum	2	1053.6	1511.4	1195.6	1195.6	1090.1	937.3
Barium	0.1	2.1	2.1	3.0	2.6	1.5	1.4
Beryllium	0.1	<	<	<	<	<	<
Boron	1	1.9	2.5	2.1	1.9	3.2	2.3
Cadmium	0.05	<	<	0.1	0.1	0.0	0.0
Calcium	7	207.7	407.0	383.5	359.8	322.9	315.5
Chromium	0.1	<	0.6	0.4	0.4	0.3	0.3
Cobalt	0.2	0.6	0.8	0.8	0.7	0.5	0.4
Copper	0.1	1.9	5.8	9.9	10.2	6.3	5.8
Iron	0.2	1491.9	1217.9	1088.2	986.2	695.8	556.2
Lead	0.4	0.4	<	0.7	0.8	0.4	0.5
Magnesium	3	105.4	259.1	168.8	119.6	218.0	140.6
Manganese	0.1	1627.3	109.6	314.5	207.4	40.7	37.7
Molybdenum	0.1	<	<	<	<	<	<
Nickel	0.2	0.4	0.6	0.5	<	0.5	0.4
Potassium	10	<	<	<	<	<	<
Silver	0.1	<	<	<	<	<	<
Sodium	6	17.7	24.5	21.5	17.3	15.9	11.0
Strontium	0.1	0.6	0.6	0.5	0.5	0.6	0.6
Sulphur	3	13.9	6.7	7.7	7.1	3.7	4.3
Thallium	0.5	<	<	<	<	<	<
Tin	0.5	<	<	<	<	<	<
Titanium	0.3	10.2	19.5	14.7	15.8	15.0	13.0
Vanadium	0.1	1.1	3.4	2.8	2.8	3.0	2.7
Zinc	0.1	1.4	8.6	25.0	26.7	17.8	13.7
Zirconium	0.5	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		4.2	15.0	36.0	37.7	25.1	20.4
AV Sulphide	0.1	<	<0.1	1.0	1.9	<0.1	<0.1
SEM/AVS Ratio		>4.2	>15	36.0	19.8	>25	>20

Table A5.4: Results of AVS/SEM Analysis Conducted on Samples from Myra Falls

Component	MDL	MF4-S umol/g	MF5-S umol/g	MF6-S umol/g	MF7-S umol/g	MN4-S umol/g	MN5-S umol/g
Aluminum	2	1858.4	1510.6	1028.9	1097.2	417.7	502.0
Barium	0.1	1.9	1.6	2.2	1.9	13.0	19.7
Beryllium	0.1	<	<	<	<	<	<
Boron	1	2.1	1.8	1.6	<	0.7	<
Cadmium	0.05	<	<	0.0	<	0.1	0.1
Calcium	7	556.0	363.2	245.6	350.8	102.5	114.9
Chromium	0.1	0.6	0.6	0.4	0.4	0.2	0.3
Cobalt	0.2	0.7	0.7	0.7	0.5	0.2	0.3
Copper	0.1	6.4	4.4	5.6	4.7	16.7	29.8
Iron	0.2	798.7	834.8	1311.6	497.3	487.1	809.1
Lead	0.4	<	<	0.4	0.2	4.5	8.3
Magnesium	3	247.8	237.4	196.4	171.4	86.0	80.3
Manganese	0.1	57.5	66.3	344.8	57.3	29.0	70.7
Molybdenum	0.1	<	<	<	<	<	<
Nickel	0.2	0.6	0.5	0.5	0.5	0.2	0.2
Potassium	10	<	<	<	<	<	<
Silver	0.1	<	<	<	<	<	<
Sodium	6	25.0	21.5	17.6	21.7	4.3	4.3
Strontium	0.1	0.8	0.6	0.4	0.5	0.4	0.6
Sulphur	3	7.5	4.4	5.5	5.8	13.6	18.6
Thallium	0.5	<	<	<	<	<	<
Tin	0.5	<	<	<	<	<	<
Titanium	0.3	26.0	20.1	15.0	12.0	2.2	2.3
Vanadium	0.1	4.0	3.1	2.4	2.8	0.7	0.7
Zinc	0.1	7.7	5.8	11.0	7.4	42.6	67.7
Zirconium	0.5	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		14.7	10.6	17.5	12.7	64.0	106.1
AV Sulphide	0.1	3.8	4.5	5.8	25.7	5.1	9.2
SEM/AVS Ratio		3.9	2.4	3.0	0.5	12.5	11.5

Table A5.4: Results of AVS/SEM Analysis Conducted on Samples from Myra Falls

Component	MDL	MN6-S umol/g	MN7-S umol/g	MN8-S umol/g	MN9-S umol/g	MN9-S umol/g Duplicate	MN10-S umol/g
Aluminum	2	1508.6	431.5	320.6	303.6	283.3	276.4
Barium	0.1	39.1	15.8	13.1	10.7	11.1	9.4
Beryllium	0.1	<	<	<	<	<	<
Boron	1	2.7	0.9	0.7	0.6	<	0.6
Cadmium	0.05	0.2	0.1	0.1	0.0	0.0	0.1
Calcium	7	258.5	87.1	66.4	61.3	74.9	65.7
Chromium	0.1	0.8	0.2	0.1	0.1	0.1	0.1
Cobalt	0.2	0.9	0.6	0.2	0.2	0.2	0.2
Copper	0.1	61.1	26.9	17.8	12.0	12.9	11.0
Iron	0.2	1956.2	709.3	488.9	313.1	274.0	374.2
Lead	0.4	12.5	6.0	3.9	2.6	2.9	1.9
Magnesium	3	281.2	40.3	29.6	62.7	30.4	27.6
Manganese	0.1	178.6	197.9	157.5	26.9	32.8	135.8
Molybdenum	0.1	<	<	<	<	<	<
Nickel	0.2	0.8	0.2	<	0.2	0.1	0.1
Potassium	10	<	<	<	<	<	<
Silver	0.1	<	<	<	<	<	<
Sodium	6	16.1	<	3.2	3.6	2.6	3.7
Strontium	0.1	1.1	0.4	0.3	0.3	0.3	0.2
Sulphur	3	37.5	15.2	12.6	9.0	8.0	8.2
Thallium	0.5	<	<	<	<	<	<
Tin	0.5	<	<	<	<	<	<
Titanium	0.3	8.9	2.6	1.9	2.3	2.1	2.2
Vanadium	0.1	2.4	0.6	0.5	0.5	0.5	0.5
Zinc	0.1	110.3	53.4	36.6	27.6	30.9	23.6
Zirconium	0.5	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		184.9	86.6	58.3	42.4	46.8	36.6
AV Sulphide	0.1	<0.1	14.4	4.4	13.2	14.0	<0.1
SEM/AVS Ratio		>185	6.0	13.3	3.2	3.3	>37

APPENDIX 6

Detailed Benthic Data and Chironomid Deformity Data

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCR									
Replicate	1	2	3	4	5	6	7	8	9	10
ROUNDWORMS										
P. Nematoda	-	-	-	3	4	-	-	-	1	2
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
F. Tricladida	5	2	14	28	-	9	-	-	2	1
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	46	5	4	1	-	-	-	3
F. Naididae										
Nais communis	-	-	1	2	-	-	-	-	-	1
Nais variabilis	-	-	-	-	-	-	-	-	-	-
F. Tubificidae										
immatures without hair chaetae	-	-	-	-	-	1	-	-	-	-
F. Lumbriculidae										
Kincaidiana hexatheca	-	-	-	-	1	-	-	-	-	4
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Hydracarina	45	19	119	88	28	12	5	32	51	43
HARPACTICOIDS										
O. Harpacticoida	-	1	54	6	13	7	1	2	8	5
SEED SHRIMPS										
Cl. Ostracoda	13	6	133	84	10	2	3	4	25	2
SPRINGTAILS										
Cl. Entognatha										
O. Collembola	2	-	1	2	2	-	1	-	4	1
INSECTS										
Cl. Insecta										
BEETLES										
O. Coleoptera										
F. Dytiscidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
F. Elmidae										
Narpus	-	-	-	-	1	-	-	-	-	-
MAYFLIES										
O. Ephemeroptera										
F. Ameletidae										
Ameletus	16	5	5	2	1	16	-	7	6	12
F. Baetidae										
indeterminate	-	-	-	-	-	-	-	-	-	-
Baetis	-	-	-	-	-	-	-	-	-	-
Baetis ?bicaudatus	3	3	13	43	1	-	2	6	-	2
F. Ephemerellidae										
indeterminate	31	12	48	38	9	2	-	8	4	8
Serratella	-	-	2	-	-	-	-	-	-	-
F. Heptageniidae										
indeterminate	36	4	13	42	-	16	4	9	1	-
Cinygmula	8	9	21	31	5	5	1	6	1	2
Epeorus	-	1	1	8	-	3	-	1	-	1
Rhithrogena	-	-	1	8	-	-	-	-	-	-
F. Leptophlebiidae										
Paraleptophlebia	9	3	11	9	3	7	-	7	2	8
STONEFLIES										
O. Plecoptera										

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCR									
Replicate	1	2	3	4	5	6	7	8	9	10
F. Capniidae										
indeterminate[a]	50	31	29	19	15	33	4	56	48	24
Capnia	-	-	1	-	2	1	-	-	-	-
F. Chloroperlidae										
indeterminate	2	1	-	7	-	2	-	-	3	-
Kathroperla	1	1	-	-	-	-	-	-	-	-
Sweltsa	32	19	52	103	24	27	5	8	27	23
F. Leuctridae										
Despaxia	-	-	-	3	-	-	-	1	1	-
Moselia	-	-	-	-	-	-	-	-	-	1
Paraleuctra	-	-	1	4	1	-	-	-	3	-
F. Nemouridae										
indeterminate	-	3	5	7	-	-	-	-	3	6
Visoka	1	1	10	4	2	1	-	1	-	-
Zapada	-	-	39	16	-	-	3	1	-	1
F. Taeniopterygidae										
indeterminate	-	-	-	3	-	-	-	-	-	-
CADDISFLIES										
O. Trichoptera										
indeterminate[b]	12	2	17	29	4	74	4	11	9	19
trichoptera pupae	1	-	-	-	-	-	-	-	-	-
F. Apataniidae										
Apatania	1	-	3	2	-	-	-	-	-	-
F. Glossosomatidae										
Glossosoma	-	-	-	2	-	-	-	-	-	-
F. Hydroptilidae										
Stactobiella	-	-	1	5	1	-	-	-	-	-
indeterminate	-	-	2	-	-	-	-	-	-	-
F. Lepidostomatidae										
Lepidostoma	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae										
Ecclisomyia	2	1	-	-	-	3	-	-	3	-
F. Polycentropodidae										
Polycentropus	-	-	-	-	-	-	-	-	-	-
F. Rhyacophilidae										
Rhyacophila	-	-	-	5	1	-	-	-	-	-
TRUE FLIES										
O. Diptera										
pupae	-	-	-	-	-	-	-	-	-	-
BITING-MIDGE										
F. Ceratopogonidae										
Bezzia	-	-	-	-	-	-	-	-	-	-
Probezzia	-	1	1	-	-	-	-	-	4	1
MIDGES										
F. Chironomidae										
Chironomid pupae	2	-	1	1	1	-	2	-	1	-
S.F. Chironominae										
Chironomus	-	-	-	-	-	-	-	-	-	-
Micropsectra	-	-	6	-	2	1	-	2	3	-
Microtendipes	-	-	-	-	-	-	-	-	-	1
Phaenopsectra	-	-	-	-	-	-	-	-	-	-
Polypedilum	2	2	49	16	4	12	-	4	17	70
indeterminate	-	-	18	-	2	-	-	1	-	6
S.F. Diamesinae										
Pagastia	-	-	7	1	-	-	-	-	-	-
S.F. Orthocladiinae										
Brillia	3	2	21	5	1	8	-	-	-	1
Chaetocladius	-	-	-	-	1	-	-	-	-	-
Corynoneura	1	2	-	-	-	1	-	-	-	-
Cricotopus	-	-	-	-	-	-	-	-	-	-
Cricotopus/Orthocladius	-	-	24	5	-	-	-	-	-	-
Eukiefferiella	2	-	14	2	-	-	-	2	-	1

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCR									
Replicate	1	2	3	4	5	6	7	8	9	10
Heleniella	-	-	-	-	-	-	-	-	1	-
Heterotrissocladius	-	-	6	-	-	-	-	1	-	6
Orthocladius	-	-	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Rheocricotopus	-	1	10	10	1	9	1	-	-	2
Rheosmittia	-	-	-	-	-	-	-	-	-	-
Smittia	-	-	-	-	-	-	-	-	-	-
Stilocladius	-	-	1	-	-	3	-	-	-	-
Synorthocladius	-	-	-	-	1	-	-	-	-	1
Thienemannia	-	-	-	-	-	-	-	-	-	-
Thienemanniella	-	-	-	-	-	-	-	-	-	1
Tvetenia	1	-	5	10	-	1	1	1	-	-
S.F. Tanypodinae										
Larsia	-	-	-	-	-	-	-	-	3	-
Thiennemannimyia complex	3	2	14	2	4	6	-	11	16	6
Zavrelimyia	1	1	-	-	-	6	-	3	21	4
indeterminate	-	-	-	-	-	-	1	1	-	-
F. Empididae										
indeterminate	-	-	-	-	-	-	-	-	-	-
Chelifera	-	-	2	1	-	-	-	1	1	-
Clinocera	-	-	2	2	-	2	-	-	1	-
Oreogeton	-	1	-	-	1	2	-	-	1	-
F. Phoridae	-	-	-	-	-	-	-	-	2	-
F. Simuliidae	-	-	-	-	-	-	-	-	-	-
F. Tipulidae										
Dicranota	3	-	6	2	2	-	-	-	1	1
Hexatoma	-	-	1	-	-	-	-	-	-	-
TOTAL NUMBER OF ORGANISMS	288	136	831	665	152	273	38	187	274	270
TOTAL NUMBER OF TAXA	26	27	44	41	31	30	14	26	31	34

[a] combination of early instar Capniidae and Leuctridae which are not separable at this life stage.
[b] trichoptera are either immature Apataniidae or Limnephilidae but are not identifiable at this life stage.

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCE									
Replicate	1	2	3	4	5	6	7	8	9	10
ROUNDWORMS										
P. Nematoda	-	-	-	1	-	-	-	-	-	1
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
F. Tricladida	5	21	7	1	-	4	1	1	1	4
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	2	2	2	-	-	34	3	33	4	14
F. Naididae										
Nais communis	-	-	4	-	-	24	-	3	2	2
Nais variabilis	-	-	-	-	-	-	1	-	-	-
F. Tubificidae										
immatures without hair chaetae	-	-	-	-	-	-	-	-	-	-
F. Lumbriculidae										
Kincaidiana hexatheca	-	-	-	-	-	4	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Hydracarina	32	41	5	8	9	26	16	12	9	14
HARPACTICOIDS										
O. Harpacticoida	-	2	-	-	-	-	-	-	-	1
SEED SHRIMPS										
Cl. Ostracoda	1	16	-	2	-	14	-	2	6	8
SPRINGTAILS										
Cl. Entognatha										
O. Collembola	3	-	-	-	1	1	1	-	-	4
INSECTS										
Cl. Insecta										
BEETLES										
O. Coleoptera										
F. Dytiscidae										
indeterminate	-	-	-	2	-	-	-	-	-	-
F. Elmidae										
Narpus	-	-	-	-	-	-	-	-	-	-
MAYFLIES										
O. Ephemeroptera										
F. Ameletidae										
Ameletus	-	2	-	2	-	-	-	-	-	4
F. Baetidae										
indeterminate	-	-	-	-	1	-	-	-	-	-
Baetis	-	-	-	-	-	-	-	2	-	-
Baetis ?bicaudatus	50	24	33	8	21	80	149	92	68	16
F. Ephemerellidae										
indeterminate	-	7	2	-	1	1	1	3	-	4
Serratella	-	-	-	-	-	-	-	-	-	-
F. Heptageniidae										
indeterminate	-	12	-	2	-	-	1	1	-	2
Cinygmula	1	2	4	1	6	3	1	3	6	12
Epeorus	1	-	-	-	-	3	1	1	3	-
Rhithrogena	-	-	-	1	-	1	-	-	-	1
F. Leptophlebiidae										
Paraleptophlebia	-	-	-	-	-	-	-	-	-	-
STONEFLIES										
O. Plecoptera										

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCE									
Replicate	1	2	3	4	5	6	7	8	9	10
F. Capniidae										
indeterminate[a]	16	170	7	1	1	14	4	8	6	7
Capnia	4	37	3	1	27	2	28	54	19	96
F. Chloroperlidae										
indeterminate	1	2	-	-	-	-	-	-	-	-
Kathroperla	-	-	-	-	-	-	-	-	-	-
Sweltsa	5	25	2	1	-	1	3	3	2	5
F. Leuctridae										
Despaxia	-	2	-	-	-	-	1	-	-	-
Moselia	-	-	-	-	-	-	-	-	-	-
Paraleuctra	-	-	-	-	-	-	-	-	-	-
F. Nemouridae										
indeterminate	-	7	-	-	-	-	1	-	-	8
Visoka	-	-	-	-	-	-	-	-	-	3
Zapada	2	-	1	-	1	4	1	9	-	3
F. Taeniopterygidae										
indeterminate	-	-	-	-	-	-	-	1	-	-
CADDISFLIES										
O. Trichoptera										
indeterminate[b]	-	3	-	-	-	-	1	-	-	5
trichoptera pupae	-	-	1	-	-	-	-	-	-	-
F. Apataniidae										
Apatania	-	-	-	-	-	-	-	-	-	-
F. Glossosomatidae										
Glossosoma	-	-	-	-	-	-	-	-	-	-
F. Hydroptilidae										
Stactobiella	-	-	1	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	-
F. Lepidostomatidae										
Lepidostoma	-	-	-	-	-	-	-	-	-	1
F. Limnephilidae										
Ecclisomyia	-	1	-	-	-	-	-	1	-	-
F. Polycentropodidae										
Polycentropus	-	-	-	-	-	-	-	-	-	1
F. Rhyacophilidae										
Rhyacophila	-	-	-	-	-	-	-	-	-	-
TRUE FLIES										
O. Diptera										
pupae	-	-	-	-	-	1	-	-	-	-
BITING-MIDGE										
F. Ceratopogonidae										
Bezzia	3	-	-	-	-	-	-	-	-	-
Probezzia	-	-	2	-	-	-	-	-	1	-
MIDGES										
F. Chironomidae										
Chironomid pupae	-	2	-	-	1	2	1	4	-	7
S.F. Chironominae										
Chironomus	-	-	-	-	-	1	-	-	-	-
Micropsectra	-	-	-	-	-	-	-	-	-	1
Microtendipes	-	-	-	-	-	-	-	-	-	-
Phaenopsectra	-	-	-	-	-	-	2	-	-	-
Polypedilum	1	7	1	-	1	-	5	10	5	23
indeterminate	-	-	-	-	1	-	-	-	-	-
S.F. Diamesinae										
Pagastia	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Brillia	3	5	1	3	9	1	7	14	3	9
Chaetocladius	-	-	-	-	-	-	-	-	-	-
Corynoneura	-	4	-	-	2	-	1	-	1	12
Cricotopus	2	6	1	1	2	2	2	-	-	-
Cricotopus/Orthocladius	2	6	5	-	4	8	3	3	3	5
Eukiefferiella	-	1	3	-	1	21	5	2	2	-

TABLE A6.1: BENTHIC INVERTEBRATES FROM MYRA CREEK, 1997.

Station	MCE									
Replicate	1	2	3	4	5	6	7	8	9	10
Heleniella	-	-	-	-	-	-	-	-	-	-
Heterotrissocladius	-	-	-	-	-	-	-	-	-	-
Orthocladius	6	1	-	-	-	-	3	2	-	-
Parametriocnemus	-	-	-	-	-	-	-	1	-	-
Rheocricotopus	-	8	-	-	1	-	17	3	2	21
Rheosmittia	-	1	-	-	-	-	-	-	-	-
Smittia	-	-	-	1	-	-	-	-	-	-
Stilocladius	-	-	-	-	-	-	2	-	-	-
Synorthocladius	-	-	-	-	-	-	-	-	-	-
Thienemannia	-	1	-	-	-	-	-	-	1	-
Thienemanniella	-	2	-	-	-	-	-	-	1	-
Tvetenia	5	9	2	-	8	16	34	22	11	10
S.F. Tanypodinae										
Larsia	-	2	-	-	1	-	-	-	-	-
Thiennemannimyia complex	5	10	2	2	2	1	16	8	13	141
Zavrelimyia	-	-	-	-	-	-	3	-	-	6
indeterminate	1	-	-	-	-	-	-	-	-	-
F. Empididae										
indeterminate	1	-	-	-	-	-	-	-	-	-
Chelifera	-	-	1	-	-	8	14	23	2	-
Clinocera	-	-	-	-	-	5	1	6	1	1
Oreogeton	1	-	-	-	-	-	1	-	-	-
F. Phoridae	-	-	-	-	-	-	-	-	-	-
F. Simuliidae	-	-	-	-	-	1	3	-	-	1
F. Tipulidae										
Dicranota	-	-	-	-	-	-	2	-	1	-
Hexatoma	1	1	-	-	-	4	-	-	-	-
TOTAL NUMBER OF ORGANISMS	154	442	90	38	101	287	336	327	173	453
TOTAL NUMBER OF TAXA	25	33	21	17	20	28	35	28	25	34

[a] combination of early instar Capniidae and Leuctridae wl
[b] trichoptera are either immature Apataniidae or Limneph

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station Replicate	MR 1	 2	 3	 4	 5	 6	 7
ROUNDWORMS							
P. Nematoda	6	4	-	8	14	4	2
FLATWORMS							
P. Platyhelminthes							
Cl. Turbellaria							
F. Neorhabdocoela	4	-	-	-	-	-	-
ANNELIDS							
P. Annelida							
WORMS							
Cl. Oligochaeta							
F. Enchytraeidae	2	-	-	-	-	-	-
F. Tubificidae							
Aulodrilus americanus	2	2	-	-	-	-	-
Rhyacodrilus montana	2	2	-	2	-	6	2
immatures with hair chaetae	-	2	-	-	-	-	-
immatures without hair chaetae	-	-	-	-	-	-	-
ARTHROPODS							
P. Arthropoda							
MITES							
Cl. Arachnida							
O. Hydracarina	8	4	6	-	2	4	6
HARPACTICOIDS							
O. Harpacticoida	26	26	24	38	48	20	24
SEED SHRIMPS							
Cl. Ostracoda	50	54	38	42	114	20	32
SPRINGTAILS							
Cl. Entognatha							
O. Collembola	-	-	-	2	-	-	-
INSECTS							
Cl. Insecta							
BEETLES							
O. Coleoptera							
F. Elmidae							
indeterminate	2	-	-	-	-	-	-
F. Staphylinidae	-	-	-	-	-	-	-
CADDISFLIES							
F. Leptoceridae							
Mystacides	-	-	-	-	-	-	-
TRUE FLIES							
O. Diptera							
BITING-MIDGE							
F. Ceratopogonidae							
Probezzia	-	-	-	-	-	-	-
Sphaeromias	-	-	-	-	-	-	-
MIDGES							
F. Chironomidae							
Chironomid pupae	-	2	-	-	-	-	-
S.F. Chironominae							
Chironomus	-	-	-	-	-	-	2
Cladopelma	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	-	-	-
Micropsectra	-	-	-	-	-	-	-
Paratendipes	-	-	-	-	-	-	-
Polypedilum	2	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station	MR						
Replicate	1	2	3	4	5	6	7
S.F. Diamesinae							
Protanypus	6	4	-	10	8	-	6
S.F. Orthocladiinae							
Corynoneura	-	-	-	-	-	-	-
Heterotrissocladius	100	86	94	70	74	62	88
Parakiefferiella	-	-	-	-	-	-	-
Tvetenia	-	-	-	-	-	-	-
S.F. Tanypodinae							
Ablabesmyia	-	-	-	-	-	-	-
Procladius	2	2	-	-	-	-	-
Thiennemannimyia complex	-	-	-	-	-	-	-
F. Empididae							
Chelifera	-	-	-	-	-	-	-
MOLLUSCS							
P. Mollusca							
CLAMS							
Cl. Pelecypoda							
F. Sphaeriidae							
Pisidium	12	4	10	8	6	4	-
TOTAL NUMBER OF ORGANISMS	224	192	172	180	266	120	162
TOTAL NUMBER OF TAXA	14	11	5	8	7	7	8

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station	MN						
Replicate	4	5	6	7	8	9	10
ROUNDWORMS							
P. Nematoda	2	4	6	2	14	8	16
FLATWORMS							
P. Platyhelminthes							
Cl. Turbellaria							
F. Neorhabdocoela	-	-	-	-	-	-	-
ANNELIDS							
P. Annelida							
WORMS							
Cl. Oligochaeta							
F. Enchytraeidae	-	2	-	6	-	-	-
F. Tubificidae							
Aulodrilus americanus	-	-	-	-	-	-	-
Rhyacodrilus montana	2	4	2	-	-	4	4
immatures with hair chaetae	-	2	-	-	-	-	-
immatures without hair chaetae	-	4	-	-	-	-	-
ARTHROPODS							
P. Arthropoda							
MITES							
Cl. Arachnida							
O. Hydracarina	16	10	2	6	3	32	26
HARPACTICOIDS							
O. Harpacticoida	1	-	-	-	-	-	-
SEED SHRIMPS							
Cl. Ostracoda	2	34	44	56	43	100	100
SPRINGTAILS							
Cl. Entognatha							
O. Collembola	-	2	-	-	-	-	-
INSECTS							
Cl. Insecta							
BEETLES							
O. Coleoptera							
F. Elmidae							
indeterminate	-	-	-	-	-	-	-
F. Staphylinidae	-	-	-	-	-	-	-
CADDISFLIES							
F. Leptoceridae							
Mystacides	-	-	-	-	-	-	2
TRUE FLIES							
O. Diptera							
BITING-MIDGE							
F. Ceratopogonidae							
Probezzia	-	-	-	-	-	-	-
Sphaeromias	-	-	-	-	-	-	-
MIDGES							
F. Chironomidae							
Chironomid pupae	-	-	4	-	9	-	2
S.F. Chironominae							
Chironomus	-	4	-	-	-	-	-
Cladopelma	-	-	-	2	-	-	-
Cladotanytarsus	-	-	-	-	-	4	-
Micropsectra	1	2	2	-	-	-	-
Paratendipes	-	-	-	-	-	-	-
Polypedilum	-	4	-	-	-	-	-
Sergentia	1	2	-	-	-	-	-
indeterminate	-	4	-	-	-	-	-

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station	MN						
Replicate	4	5	6	7	8	9	10
S.F. Diamesinae							
Protanypus	3	2	2	6	4	-	4
S.F. Orthocladiinae							
Corynoneura	-	-	-	-	-	4	-
Heterotrissocladius	15	16	90	44	52	20	34
Parakiefferiella	-	10	2	2	-	58	-
Tvetenia	-	-	-	-	-	-	-
S.F. Tanypodinae							
Ablabesmyia	-	2	-	-	-	-	-
Procladius	-	-	-	-	2	-	2
Thiennemannimyia complex	-	-	-	-	-	-	-
F. Empididae							
Chelifera	-	-	-	-	-	-	-
<u>MOLLUSCS</u>							
P. Mollusca							
CLAMS							
Cl. Pelecypoda							
F. Sphaeriidae							
Pisidium	-	-	-	-	-	-	-
TOTAL NUMBER OF ORGANISMS	43	108	154	124	127	230	190
TOTAL NUMBER OF TAXA	9	17	8	8	6	8	8

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station	MF						
Replicate	1	2	3	4	5	6	7
ROUNDWORMS							
P. Nematoda	20	6	6	12	6	10	30
FLATWORMS							
P. Platyhelminthes							
Cl. Turbellaria							
F. Neorhabdocoela	-	-	-	-	-	-	-
ANNELIDS							
P. Annelida							
WORMS							
Cl. Oligochaeta							
F. Enchytraeidae	4	-	-	-	2	-	-
F. Tubificidae							
Aulodrilus americanus	-	2	8	2	2	2	2
Rhyacodrilus montana	-	2	2	-	-	-	-
immatures with hair chaetae	-	-	-	-	-	-	-
immatures without hair chaetae	-	-	4	-	-	-	-
ARTHROPODS							
P. Arthropoda							
MITES							
Cl. Arachnida							
O. Hydracarina	4	2	8	-	2	2	2
HARPACTICOIDS							
O. Harpacticoida	-	-	-	-	-	-	-
SEED SHRIMPS							
Cl. Ostracoda	6	8	34	58	54	72	42
SPRINGTAILS							
Cl. Entognatha							
O. Collembola	-	-	-	-	-	-	-
INSECTS							
Cl. Insecta							
BEETLES							
O. Coleoptera							
F. Elmidae							
indeterminate	-	-	-	-	-	-	-
F. Staphylinidae	-	-	-	2	-	-	-
CADDISFLIES							
F. Leptoceridae							
Mystacides	-	-	-	-	-	-	-
TRUE FLIES							
O. Diptera							
BITING-MIDGE							
F. Ceratopogonidae							
Probezzia	2	-	-	-	-	-	-
Sphaeromias	-	-	2	-	-	-	-
MIDGES							
F. Chironomidae							
Chironomid pupae	-	2	2	-	-	-	4
S.F. Chironominae							
Chironomus	-	-	2	-	-	-	-
Cladopelma	-	-	-	-	-	-	-
Cladotanytarsus	-	2	-	-	-	-	-
Micropsectra	2	-	8	-	-	-	-
Paratendipes	-	-	6	2	-	-	-
Polypedilum	-	-	-	-	-	-	-
Sergentia	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-

TABLE A6.2: BENTHIC INVERTEBRATES FROM BREWSTER AND BUTTLE LAKE, 1997.

Station	MF						
Replicate	1	2	3	4	5	6	7
S.F. Diamesinae							
Protanypus	-	2	4	-	2	-	-
S.F. Orthocladiinae							
Corynoneura	-	-	-	-	-	-	-
Heterotrissocladius	22	44	38	26	28	48	64
Parakiefferiella	-	-	-	-	-	-	-
Tvetenia	-	-	-	-	-	-	-
S.F. Tanypodinae							
Ablabesmyia	2	2	2	2	-	-	-
Procladius	2	-	-	4	-	-	-
Thiennemannimyia complex	-	-	2	2	-	2	-
F. Empididae							
Chelifera	-	-	2	-	-	-	2
<u>MOLLUSCS</u>							
P. Mollusca							
CLAMS							
Cl. Pelecypoda							
F. Sphaeriidae							
Pisidium	-	-	-	-	-	-	-
TOTAL NUMBER OF ORGANISMS	64	72	130	110	96	136	146
TOTAL NUMBER OF TAXA	9	9	15	9	7	6	6

Table A6.3: Summary of Chironomid Abnormalities, Myra Creek, September 1997.

Station	No. Chironomids per sample fraction	Number examined	% Showing abnormalities	Genus showing abnormality	Noted abnormality
MR1	27	16	0	none	
MR2	17	12	0	none	
MR3	23	10	0	none	
MR4	38	18	6	*Protanypus*	missing 1 inner tooth left mandible
MR5	30	14	14	*Protanypus* *Heterotrissocladius*	missing 1 inner tooth left mandible middle mental teeth fused
MR6	26	11	0	none	
MR7	36	14	7	*Heterotrissocladius*	1 centre tooth chipped
MN4	16	10	30	*Sergentia* *Protanypus* *Protanypus*	broken tooth left mandible left mental lateral teeth worn missing 1 inner tooth left mandible
MN5	15	15	0	none	
MN6	45	17	0	none	
MN7	26	15	0	none	
MN8	52	22	5	*Heterotrissocladius*	mentum with extra centre tooth
MN9	9	9	0	none	
MN10	18	11	0	none	
MF1	12	7	14	*Heterotrissocladius*	missing 1 inner tooth on left mandible
MF2	22	7	29	*Heterotrissocladius* *Heterotrissocladius*	centre teeth of mentum worn centre teeth of mentum worn
MF3	25	17	12	*Protanypus* *Chironomus*	broken tooth right mandible centre tooth of mentum broken
MF4	17	9	11	*Procladius*	ligula with bifid outer right tooth
MF5	15	6	0	none	
MF6	23	10	10	*Heterotrissocladius*	mentum with chipped centre tooth
MF7	30	16	0	none	

Table A6.4: Summary of Chironomid Abnormalities, Brewster and Buttle Lakes, September 1997.

Station	No. Chironomids per sample fraction	Number examined	% Showing abnormalities	Genus showing abnormality	Noted abnormality
MCR1	5	5	40	*Brillia* *Brillia*	broken apical tooth on left mandible center teeth fused
MCR2	5	5	0	none	
MCR3	42	29	10	*Brillia* *Brillia* *Brillia*	broken apical tooth on left mandible broken apical tooth on left mandible broken inner tooth on right mandible
MCR4	10	10	10	*Rheocricotopus*	several mental teeth broken
MCR5	4	4	0	none	
MCR6	12	12	0	none	
MCR7	2	2	50	*Rheocricotopus*	both apical mandibular teeth broken
MCR8	13	6	17	*Tvetenia*	left centre tooth of mentum worn
MCR9	26	8	0	none	
MCR10	13	10	0	none	
MCE1	9	9	33	*Tvetenia* *Orthocladius/Cricotopus* *Orthocladius/Cricotopus*	apical tooth on right mandible broken centre tooth chipped centre tooth chipped
MCE2	30	21	14	*Cricotopus* *Brillia* *Brillia*	centre tooth chipped apical tooth on left mandible broken centre teeth of mentum fused; 1st lateral smaller on the right
MCE3	7	7	14	*Orthocladius/Cricotopus*	right 1st lateral of mentum worn
MCE4	3	3	0	none	
MCE5	20	15	7	*Orthocladius/Cricotopus*	left mandible with bifid apical tooth
MCE6	10	6	0	none	
MCE7	34	19	5	*Cricotopus*	worn centre tooth
MCE8	20	10	10	*Orthocladius/Cricotopus*	worn centre tooth
MCE9	23	13	8	*Rheocricotopus*	chipped left centre tooth
MCE10	59	10	20	*Rheocricotopus* *Zavrelimyia*	chipped right centre tooth ligula with broken right 1st lateral

TABLE A6.4: IDENTIFICATION LEVELS FOR INVERTEBRATE GROUPS AND TAXONOMIC REFERENCES

Group	Taxonomic Level	Taxonomic References
Oligochaeta	Species	Brinkhurst, 1986
Polychaeta	Species	Klemm, 1985
Hirudinea	Species	Klemm, 1991
Nemertea	Genus	Pennak, 1989
Ephemeroptera	Genus/Species	Edmunds, 1976; Merritt and Cummins, 1984
Heptageniidae	Species	Bednarik and McCafferty, 1979
Ephemeridae	Genus/Species	McCafferty, 1974
Plecoptera	Genus/Species	Stewart and Stark, 1988; Merritt and Cummins, 1984
Odonata	Genus/Species	Merritt and Cummins, 1984; Walker and Corbet, 1975
Trichoptera	Genus/Species	Wiggins, 1977, Merritt and Cummins, 1984
Coleoptera	Genus/Species	Merritt and Cummins, 1984
Megaloptera	Genus	Merritt and Cummins, 1984
Hemiptera	Species	Hilsenhoff, 1981
Homoptera	Order	Merritt and Cummins, 1984
Lepidoptera	Family	Merritt and Cummins, 1984
Chironomidae	Genus	Wiederholm, 1983; Oliver and Roussel, 1983
Diptera	Genus	Merritt and Cummins, 1984
Amphipoda	Genus	Holsinger, 1976; Bousfield, 1967
Isopoda	Genus	Pennak, 1989
Decapoda	Species	Hobbs, 1976; Crocker and Barr, 1968
Mysidacea	Species	Pennak, 1989
Gastropoda	Genus/Species	Burch, 1989; Clarke, 1981
Pelecypoda	Genus (Pisidium)	Clarke, 1981
Pelecypoda	Species (Sphaerium)	Mackie *et al.*, 1980; Clarke, 1981
Unionidae	Species	Clarke, 1981
Coelenterata	Genus	Pennak, 1989
Acarina	Class	Thorp and Covich, 1991
Nematoda	Phylum	Pennak, 1989
Turbellaria	Class	Pennak, 1989
Ostracoda	Class	Pennak, 1989
Harpacticoida	Order	Pennak, 1989
Tardigrada	Class	Pennak, 1989
Collembola	Order	Thorp and Covich, 1991

APPENDIX 7

Effluent and Sediment Toxicity

beak international incorporated

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Brampton,Ontario
Canada L6T 5B7

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1-800-361-BEAK (2325

QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia* . EPS 1/RM/21.

Reference Toxicant Test # 9700562-0:

Chemical Used:	Sodium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	2630 mg/L
Historical Warning Limits (LC50):	1180 - 2530
Historical Control Limits (LC50):	844 - 2870
7-Day IC50:	1700 mg/L
Historical Warning Limits (IC50):	1170 - 1980
Historical Control Limits (IC50):	963 - 2180

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The IC50, which estimates survival and reproduction effects, is within the established historical limits; however, the LC50 value, which measures survival alone, is above the historical warning limit. This may occur due to chance alone, once every 20 tests or may indicate a problem with the test system. An investigation revealed no anomalies in test system, cultures or technical performance and limits were recalculated using the latest data.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

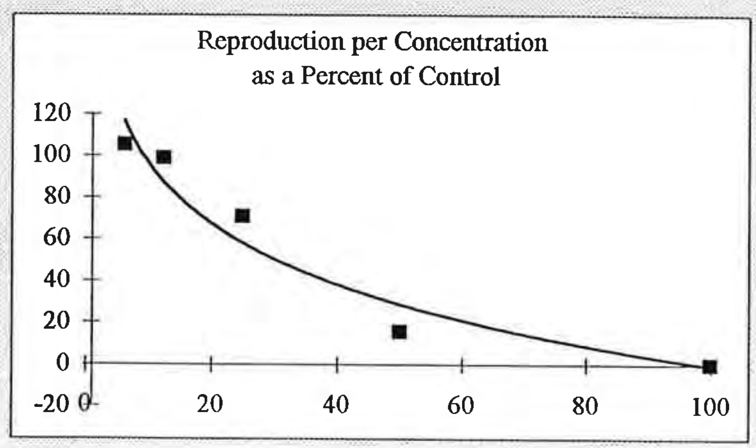
beak

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario

Sample:	MF-R-S (M-E-1)		
Sample Type:	effluent		
Test No.:	9700633-2	**Date Initiated:**	3-Jul-97
Date Sampled:	2-Jul-97	**Time Initiated:**	16:30
Time Sampled:	12:00	**Initiated by:**	E. Jonczyk



TEST DATA

Total Number of Neonates Produced per Adult After 7 Days of Testing

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	30	36	31	33	8	0
2	33	26	14	8	0	0
3	25	26	23	14	0	0
4	37	38	40	31	10	0
5	27	15	26	19	0	0
6	25	25	25	15	6	0
7	13	22	17	27	0	0
8	21	30	37	20	11	0
9	22	29	18	15	0	0
10	27	27	26	2	5	0
mean / conc.	26.0	27.4	25.7	18.4	4.0	0.0
mortality / 10 adults	1	0	0	1	5	10

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.4	1266	24.1	9.5	730	40

Sample treatments: Sample was preaerated 20 minutes on Day 3 prior to dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	22.2	13.4-29.8	Linear Interpolation,	
IC50	33.8	23.8-38.8	(Norberg-King, 1993)	
LC50	46.7	36.1-60.2	Spearman-Karber	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700562-0

Reported by: [signature] Date: Jan. 15/98

beak international incorporated

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QUALITY ASSURANCE INFORMATION: 7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	Aquatic Research Organisms, New Hampshire
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700599-0

Chemical Used:	Potassium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	964 mg/L
Historical Warning Limits (LC50):	785 - 1050
Historical Control Limits (LC50):	720 - 1113
IC50:	1610 mg/L
Historical Warning Limits (IC50):	672 - 1600
Historical Control Limits (IC50):	440 - 1830

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits (± 1%).
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

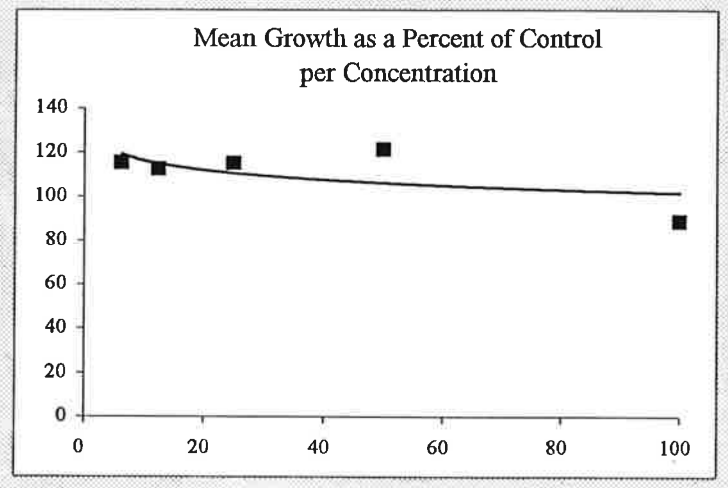
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

Fathead Minnow Survival and Growth Test

Biological Test Method EPS 1/RM/22 *

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario		
Sample:	MF-R-S (M-E-1)		
Sample Type:	effluent		
Test No.:	9700633-3	**Date Initiated:**	3-Jul-97
Date Sampled:	2-Jul-97	**Time Initiated:**	16:45
Time Sampled	12:00	**Initiated by:**	E. Jonczyk



TEST DATA

Mean Fish Weight per Replicate (mg)

replicate	0	6.25	12.5	25	50	100
	concentration (% v/v)					
1	0.550	0.676	0.648	0.641	0.723	0.498
2	0.622	0.708	0.657	0.683	0.662	0.480
3	0.533	0.654	0.722	0.670	0.750	0.491
4	0.620	0.642	0.582	0.678	0.681	0.589
mean / conc.	0.581	0.670	0.652	0.668	0.704	0.515

Survival per Replicate (total exposed per concentration = 40)

replicate	0	6.25	12.5	25**	50	100
	concentration (% v/v)					
1	8	10	8	10	10	5
2	10	9	10	10	9	9
3	9	10	10	10	10	9
4	9	9	10	10	8	8
total survival	36	38	38	40	37	31
proportion	0.90	0.95	0.95	0.98	0.93	0.78

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.4	1266	24.1	9.5	730	40

Sample treatments: Sample was preaerated on Days 3 and 5 prior to dilution.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	>100	na	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	>100	na		surviving fish only.
LC50	>100	na	na	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700599-0

** 41 organisms were exposed in the 12.5% concentration.

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan. 15/98

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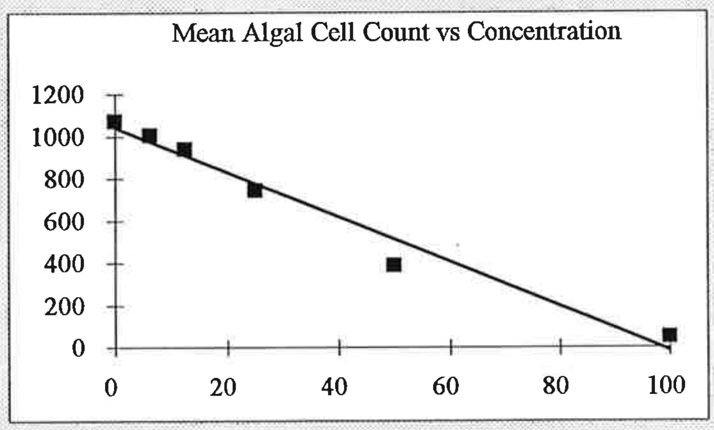
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Beak

Sample: $ZnSO_4$

Sample No.:	9700675-0	**Date Initiated:**	16-Jul-97
Date Sampled:	na	**Time Initiated:**	17:15
Time Sampled:	na	**Initiated by:**	E. Jonczyk



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (µg/L)					
replicate	0	6.25	12.5	25	50	100
1	1086	919	969	777	383	49
2	994	1128	877	668	333	24
3	1145	1019	1002	743	392	74
4	1078	969	944	743	442	65
5	1053	986	902	785	392	32
mean / conc.	1071.1	1004.1	938.9	743.1	388.4	48.8

TEST RESULTS

	µg/L	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	6.25	na	Dunnett's	7	
LOEC	12.5	na			
TEC	8.84	na			
IC25	21.2	17.1 - 24.7	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	39.6	35.9 - 42.7			

QUALITY ASSURANCE / COMMENTS

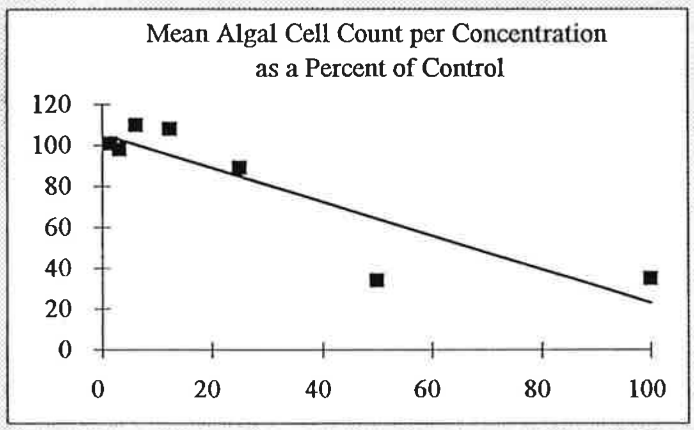
E.B. Eddy Algae Batch used in Reference Toxicant Test
No significant difference was found between control growth and growth in the QA/QC plate.
CV of control group = 5%

Reported by: [signature]

Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario		
Sample:	MF-R-B (M-E-1)		
Sample No.:	9700633-4	**Date Initiated:**	4-Jul-97
Date Sampled:	2-Jul-97	**Time Initiated:**	15:15
Time Sampled:	12:00	**Initiated by:**	E. Jonczyk



TEST DATA

Mean Algal Cell Count Determined Via Absorbance
(cells/ml = cell count x 10,000)

	concentration (% v/v)							
replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	113	121	126	126	134	98	14	29
2	126	118	113	121	131	116	73	44
3	116	126	124	144	129	96	32	34
4	126	118	108	136	126	118	44	60
mean / conc.	120.4	121.0	117.9	131.9	130.0	107.0	40.6	41.9

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	31.4	24.9 - 37.4	Linear Interpolation, (Norberg-King, 1993)	
IC50	42.8	37.3 - 66.2		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700675-0
CV of vertical control group = 6%
CV of entire control group= 7%
Growth in the control was higher than growth in the qa/qc plate.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.

Reference Toxicant Test # 9700810-0

Chemical Used:	Sodium Chloride
Date of Test:	8-Sep-97
7-Day LC50:	1770 mg/L
Historical Warning Limits (LC50):	1170 - 2540
Historical Control Limits (LC50):	825 - 2880
7-Day IC50:	1210 mg/L
Historical Warning Limits (IC50):	1120 - 1960
Historical Control Limits (IC50):	906 - 2170

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

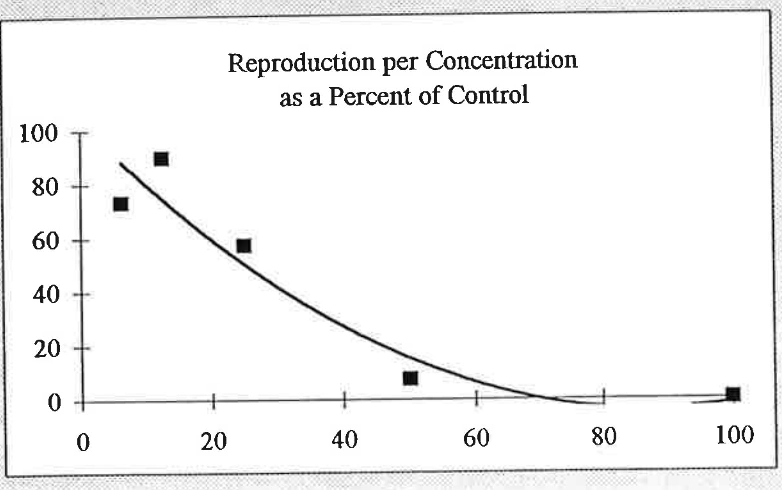
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Westmin Resources Ltd. (Myra Falls)
Campbell River, Ontario

Sample: MF-R-S (M-E-2)
Sample Type: effluent
Test No.: 9700758-2 **Date Initiated:** 28-Aug-97 *
Date Sampled: 13-Aug-97 **Time Initiated:** 17:15
Initiated by: E. Jonczyk



TEST DATA
Total Number of Neonates Produced per Adult After 7 Days of Testing

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	47	37	47	32	0	0
2	38	14	27	33	0	0
3	23	29	34	22	0	0
4	20	21	26	5	1	0
5	20	27	39	23	2	0
6	34	28	24	17	0	0
7	23	40	30	28	21	0
8	41	2	18	7	0	0
9	36	16	17	17	0	0
10	48	27	34	4	0	0
mean / conc.	33.0	24.1	29.6	18.8	2.4	0.0
mortality / 10 adults	1	0	0	1	2	6

Sample Appearance: clear,colourless

Initial Parameters:

DO (mg/L)	8.2	Conductivity (µmhos/cm)	1465	Temperature (°C)	24.9	pH	7.59	Hardness (mg/L)	985	Alkalinity (mg/L)	80

Sample treatments:

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	15.8	4.30 - 26.8	Linear Interpolation,	
IC50	28.5	19.8 - 35.9	(Norberg-King, 1993)	
LC50	89.1	66.1 - 180	Probit	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700810-0

* Test originally initiated on August 15. Poor reproduction was observed in the receiving water control group; which did not meet test validity requirements. Test was reset on August 28.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION: 7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700740-0

Chemical Used:	Potassium Chloride
Date of Test:	11-Aug-97
7-Day LC50:	868 mg/L
Historical Warning Limits (LC50):	771 - 1030
Historical Control Limits (LC50):	707 - 1090
IC50:	1100 mg/L
Historical Warning Limits (IC50):	705 - 1490
Historical Control Limits (IC50):	510 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

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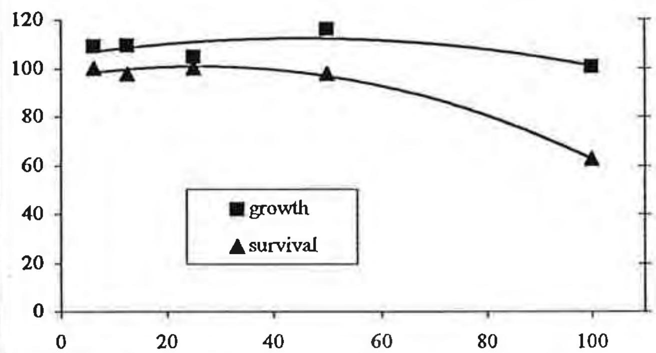
Fathead Minnow Survival and Growth Test

Biological Test Method EPS 1/RM/22 *

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario		
Sample:	MF-R-S (ME-2)		
Sample Type:	effluent		
Test No.:	9700758-3	**Date Initiated:**	14-Aug-97
Date Sampled:	13-Aug-97	**Time Initiated:**	19:00
		Initiated by:	J. Schroeder

Mean Growth as a Percent of Control and Proportion Surviving Per Concentration



TEST DATA

Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	1.102	1.338	1.277	1.283	1.324	1.220
2	1.146	1.073	1.186	1.105	1.323	1.053
3	1.060	1.286	1.116	1.144	1.298	1.162
4	1.197	1.210	1.344	1.177	1.270	1.083
mean / conc.	1.126	1.227	1.231	1.177	1.304	1.130

Survival per Replicate (total exposed per concentration = 40)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	6	10	10	10	9	7
2	10	10	10	10	10	6
3	10	10	10	10	10	5
4	10	10	9	10	10	7
total survival	36	40	39	40	39	25
proportion	0.90	1.00	0.98	1.00	0.98	0.63

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.4	1434	24.3	10.31	890	65

Sample treatments:

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	>100	na	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	>100	na		surviving fish only.
LC50	>100	na	na	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700740-0

Survival in the 100% concentration was reduced by 38%.

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan - 15/98

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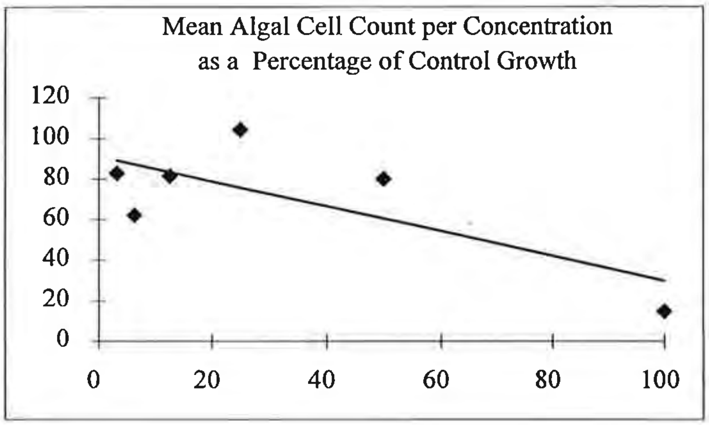
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Beak

Sample: $ZnSO_4$

Sample No.:	9700809-0	**Date Initiated:**	22-Aug-97
Date Sampled:	na	**Time Initiated:**	16:00
Time Sampled:	na	**Initiated by:**	R. Dorosz



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (µg/L)						
replicate	0	3.13	6.25	12.5	25	50	100
1	88	70	55	81	102	74	12
2	99	74	59	74	99	81	12
3	95	84	59	81	110	81	16
4	106	95	74	88	106	88	19
5	117	95	66	88	110	81	16
mean / conc.	101.0	83.7	62.7	82.2	105.3	80.8	15.0

TEST RESULTS

	µg/L	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	<3.13	na	William's test	na	
LOEC	3.13	na			
TEC	<3.13	na			
IC25	53.8	11.8 - 61.8	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	73.0	67.0 - 77.5			

QUALITY ASSURANCE / COMMENTS

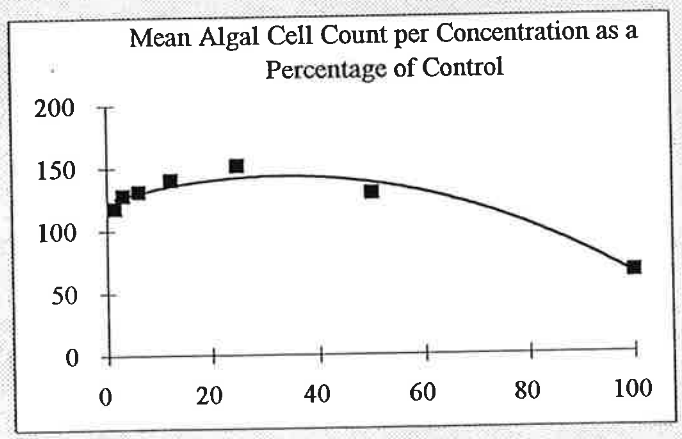
Growth in the QA/QC plate was found to be significantly lower (9%) than in the control.
CV of control group = 11%

Reported by: [signature]

Date: Jan. 15/98

Algal Growth Inhibition Test
Biological Test Method EPS 1/RM/25

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario
Sample:	MF-R-B (M-E-2)
Sample No.:	9700758-4
Date Sampled:	13-Aug-97
Date Initiated:	15-Aug-97
Time Initiated:	15:40
Initiated by:	R. Dorosz



TEST DATA
Mean Algal Cell Count Determined Via Absorbance
(cells/ml = cell count x 10,000)

	concentration (% v/v)							
replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	118	136	150	154	164	182	150	74
2	107	139	150	154	161	172	150	71
3	125	146	154	161	179	186	161	89
4	121	132	146	146	154	172	146	71
mean / conc.	117.6	138.3	150.0	153.6	164.4	177.9	151.8	76.2

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	71	not calculable	Linear Interpolation, (Norberg-King, 1993)	
IC50	>100	na		

QUALITY ASSURANCE / COMMENTS
Associated QA/QC test: 9700809-0
CV of vertical control group = 7% ; CV of entire control group = 9%
Concentrations with mean algal cell counts > mean control cell counts were excluded from the IC25 and IC50 determination, as recommended by the Environment Canada protocol.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.

Reference Toxicant Test # 9700810-0

Chemical Used:	Sodium Chloride
Date of Test:	8-Sep-97
7-Day LC50:	1770 mg/L
Historical Warning Limits (LC50):	1170 - 2540
Historical Control Limits (LC50):	825 - 2880
7-Day IC50:	1210 mg/L
Historical Warning Limits (IC50):	1120 - 1960
Historical Control Limits (IC50):	906 - 2170

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

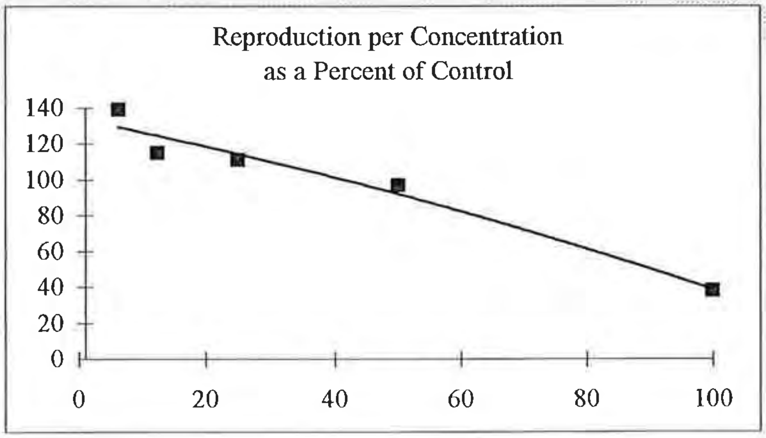
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test
Biological Test Method EPS 1/RM/21

Client: Westmin Resources Ltd. (Myra Falls)
Campbell River, Ontario

Sample: MF-R-S (M-E-3)
Sample Type: effluent
Test No.: 9700967-2 **Date Initiated:** 2-Oct-97
Date Sampled: 30-Sep-97 **Time Initiated:** 19:30
Initiated by: E. Jonczyk



TEST DATA **Total Number of Neonates Produced per Adult After 8 Days of Testing**

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	37	38	40	43	38	13
2	52	44	38	37	31	17
3	36	44	38	35	43	2
4	29	41	38	35	32	14
5	34	70	39	37	47	16
6	19	48	62	38	25	8
7	43	44	36	49	42	14
8	28	49	34	32	0	0
9	25	35	31	37	35	20
10	32	52	29	28	31	23
mean / conc.	33.5	46.5	38.5	37.1	32.4	12.7
mortality / 10 adults	0	0	0	0	1	0

Sample Appearance: Clear, colourless.
Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.9	1103	23.7	9.68	580	35

Sample treatments: Sample was preaerated for 20 minutes on Day 0 prior to dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	56.1	36.2 - 67.0	Linear Interpolation,	
IC50	81.5	65.9 - 91.5	(Norberg-King, 1993)	
LC50	>100	na	na	

QUALITY ASSURANCE INFORMATION & COMMENTS
Associated QA/QC test: 9700810-0

Reported by: [signature] Date: Jan 15/98

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QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700966-0

Chemical Used:	Potassium Chloride
Date of Test:	28-Sep-97
7-Day LC50:	899 mg/L
Historical Warning Limits (LC50):	773 - 1030
Historical Control Limits (LC50):	710 - 1090
IC50:	996 mg/L
Historical Warning Limits (IC50):	698 - 1480
Historical Control Limits (IC50):	501 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

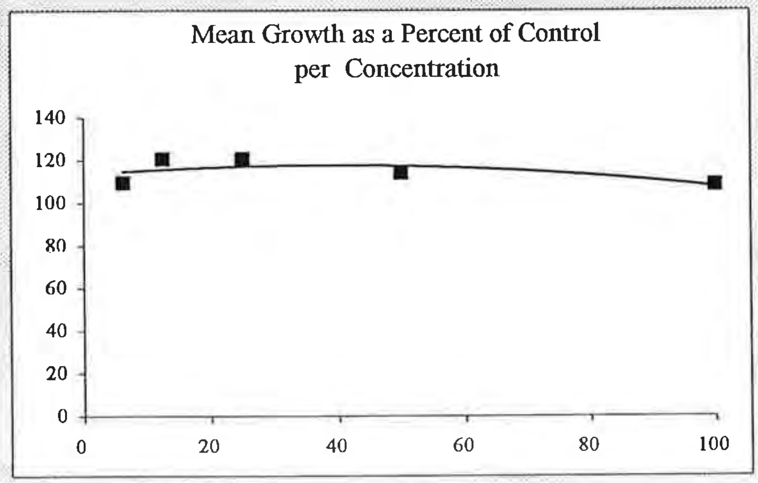
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

Fathead Minnow Survival and Growth Test

Biological Test Method EPS 1/RM/22 *

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario
Sample:	MF-S-S (M-E-3)
Sample Type:	effluent
Test No.:	9700967-3
Date Sampled:	30-Sep-97
Date Initiated:	1-Oct-97
Time Initiated:	22:00
Initiated by:	J. Schroeder



TEST DATA

Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	0.845	0.872	0.998	1.031	1.065	0.955
2	0.820	0.988	1.039	0.928	0.919	0.961
3	0.899	0.940	1.044	1.129	0.929	0.851
mean / conc.	0.855	0.933	1.027	1.029	0.971	0.922

Proportion Surviving per Replicate
(total exposed per concentration = 30)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	1.0	0.9	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	0.9	1.0	1.0
mean / conc.	1.00	0.97	1.00	0.97	1.00	1.00

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.9	1103	23.7	9.68	580	35

Sample treatments: none

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	>100	na	Linear Interpolation, (Norberg-King, 1993)	
IC50	>100	na		
LC50	>100	na	na	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700966-0

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION:

72hr. Algal Growth Inhibition Test

Test Conditons

Test Temperature:	25±1°C
Lighting (lux intensity):	4000±10%
Dilution Water:	Filtered algal medium
Test Volume:	220 µL
Test Organism:	*Selenastrum capricornutum*
Organism Source:	In House Culture
Organism Age:	4-7 days (in exponential growth)
Initial Algal Innoculum:	10 000 cells/mL

Protocol

Environment Canada. 1992. Biological Test Method: Growth Inhibition Test Using the Freshwater Alga *Selenastrum capricornutum*. EPS 1/RM/21

Reference Toxicant Test # 9700997-0

Chemical Used:	Zinc Sulfate
Date of Test:	10-Oct-97
IC25:	35.4 µL/L
Historical Warning Limits (IC25):	4.6 - 55.4
Historical Control Limits (IC25):	-8.0 - 68.1
IC50:	49.8 µL/L
Historical Warning Limits (IC50):	22.6 - 76.8
Historical Control Limits (IC50):	9.0 - 90.4

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using zinc sulfate at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.
na	not applicable

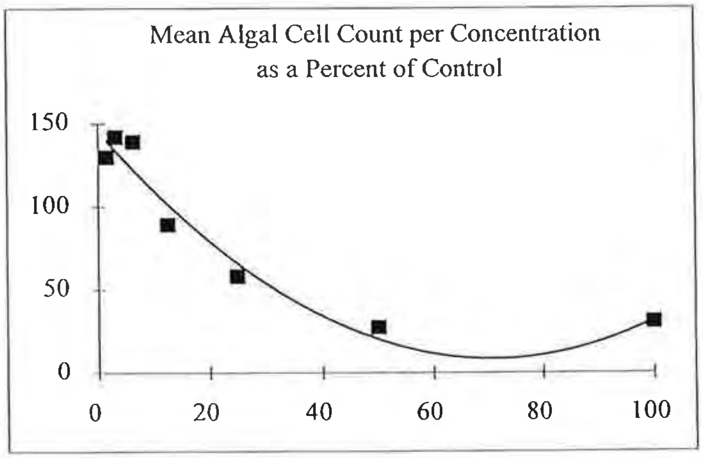
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Westmin Resources Ltd. (Myra Falls)
Campbell River, Ontario

Sample: MF-R-B (M-E-3)

Sample No.: 9700967-5 **Date Initiated:** 2-Oct-97
Date Sampled: 30-Sep-97 **Time Initiated:** 18:00
Initiated by: P. Trainor



TEST DATA

Mean Algal Cell Count Determined Via Absorbance
(cells/ml = cell count x 10,000)

	concentration (% v/v)							
replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	249	317	359	310	174	163	76	76
2	287	317	362	276	216	114	57	69
3	216	340	340	468	208	144	69	91
4	223	291	321	302	268	144	65	61
mean / conc.	243.8	316.3	345.4	338.8	216.5	141.2	66.8	74.3

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	18.1	8.70 - 23.6	Linear Interpolation, (Norberg-King, 1993)	
IC50	31.8	19.9 - 40.0		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700997-0
CV of vertical control group = 13%; CV of entire control group = 20%
There was no significant difference found between growth in the control and QA/QC plate growth.
Concentrations with mean algal cell counts > mean control cell counts were excluded from the IC25 and IC50 determination, as recommended by the Environment Canada protocol.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.
BEAK Reference: SOP CD - 3

Reference Toxicant Test # 9701230-0

Chemical Used:	Sodium Chloride
Date of Test:	1-Dec-97
6-Day LC50:	1770 mg/L
Historical Warning Limits (LC50):	1160 - 2590
Historical Control Limits (LC50):	807 - 2940
6-Day IC50:	1110 mg/L
Historical Warning Limits (IC50):	1040 - 1960
Historical Control Limits (IC50):	817 - 2190

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

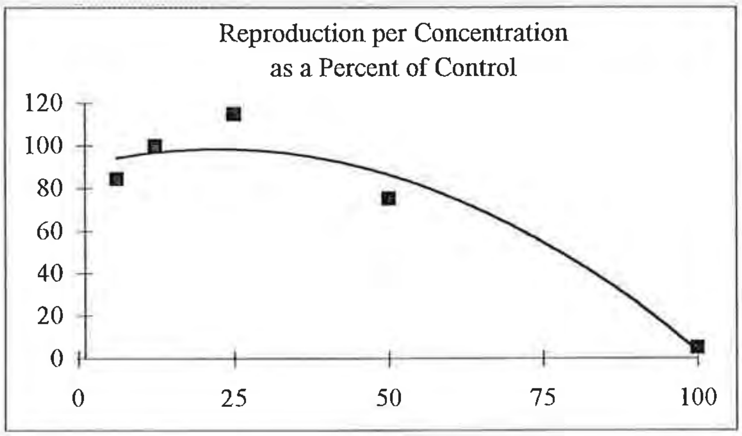
The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test
Biological Test Method EPS 1/RM/21

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario		
Sample:	MF-R-S (M-E-4)		
Sample Type:	effluent		
Test No.:	9701339-3	**Date Initiated:**	2-Dec-97
Date Sampled:	1-Dec-97	**Time Initiated:**	16:45
		Initiated by:	E. Jonczyk



TEST DATA Total Number of Neonates Produced per Adult After 8 Days of Testing

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	23	8	17	21	0	0
2	36	34	33	29	0	0
3	18	14	24	23	28	0
4	30	17	39	42	37	0
5	37	40	35	*	40	0
6	20	27	45	47	4	0
7	29	12	19	27	36	0
8	3	2	15	29	15	12
9	18	5	0	0	18	0
10	31	47	17	35	5	0
mean / conc.	24.5	20.6	24.4	28.1	18.3	1.2
mortality / 10 adults	0	2	1	1	4	9

Sample Appearance: clear
Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
9.5	896	25.9	9.56	480	10

Sample treatments: Sample was preaerated for 20 minutes prior to each dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	49.7	12.0 - 63.2	Linear Interpolation,	
IC50	67.7	42.0 - 76.5	(Norberg-King, 1993)	
LC50	53.8	37.3 - 80.6	Moving Average	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9701230-0

* 9 organisms were exposed in the 25% concentration.

Reported by: [signature] Date: Jan 15/98

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QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	300 ml per replicate
Test Vessels:	420 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9701096-0

Chemical Used:	Potassium Chloride
Date of Test:	6-Nov-97
7-Day LC50:	884 mg/L
Historical Warning Limits (LC50):	772 - 1020
Historical Control Limits (LC50):	710 - 1080
IC50:	923 mg/L
Historical Warning Limits (IC50):	681 - 1480
Historical Control Limits (IC50):	481 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

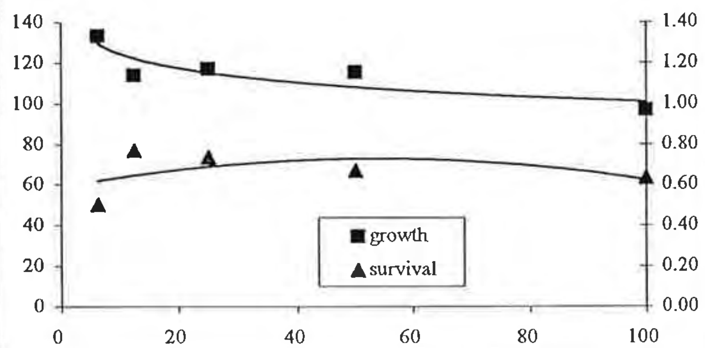
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different

Fathead Minnow Survival and Growth Test
Biological Test Method EPS 1/RM/22 *

Client: Westmin Resources Ltd. (Myra Falls)
Campbell River, Ontario

Sample: MF-S-S (M-E-4)
Sample Type: effluent
Test No.: 9701339-5 **Date Initiated:** 2-Dec-97
Date Sampled: 1-Dec-97 **Time Initiated:** 17:30
Initiated by: P. Trainor

Mean Growth as a Percent of Control
and Proportion Surviving Per Concentration



TEST DATA
Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	0.729	1.040	0.799	0.840	0.731	0.720
2	0.784	0.936	0.907	0.897	0.876	0.647
3	0.768	1.058	0.886	0.927	1.024	0.838
mean / conc.	0.760	1.011	0.864	0.888	0.877	0.735

Proportion Surviving per Replicate
(total exposed per concentration =30)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	0.7	0.5	0.8	0.7	0.8	0.6
2	0.8	0.5	0.7	0.8	0.7	0.7
3	1.0	0.5	0.8	0.7	0.5	0.6
mean / conc.	0.83	0.50	0.77	0.73	0.67	0.63

Sample Appearance: clear, colourless
Initial Parameters:

DO (mg/L)	9.5	Conductivity (µmhos/cm)	896	Temperature (°C)	25.9	pH	9.56	Hardness (mg/L)	480	Alkalinity (mg/L)	10

Sample treatments: Sample was preareated for 20 minutes on each day of testing, prior to dilution.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	>100	na	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	>100	na		surviving fish only.
LC50	>100	na	na	

QUALITY ASSURANCE / COMMENTS
Associated QA/QC test: 9701096-0
Survival in the 100% concentration was reduced by 38%.
* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan. 15/98

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QUALITY ASSURANCE INFORMATION: 72hr. Algal Growth Inhibition Test

Test Conditons

Test Temperature:	25±1°C
Lighting (lux intensity):	4000±10%
Dilution Water:	Filtered algal medium
Test Volume:	220 µL
Test Organism:	*Selenastrum capricornutum*
Organism Source:	In House Culture
Organism Age:	4-7 days (in exponential growth)
Initial Algal Innoculum:	10 000 cells/mL

Protocol

Environment Canada. 1992. Biological Test Method: Growth Inhibition Test Using the Freshwater Alga *Selenastrum capricornutum*. EPS 1/RM/21
BEAK Reference: SOP SE - 2

Reference Toxicant Test # 9701277-0

Chemical Used:	Zinc Sulfate
Date of Test:	4-Dec-97
IC25:	31.7 µL/L
Historical Warning Limits (IC25):	6.2 - 52.9
Historical Control Limits (IC25):	-5.5 - 64.6
IC50:	45.1 µL/L
Historical Warning Limits (IC50):	24.5 - 76.3
Historical Control Limits (IC50):	11.5 - 89.3

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using zinc sulfate at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:
The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

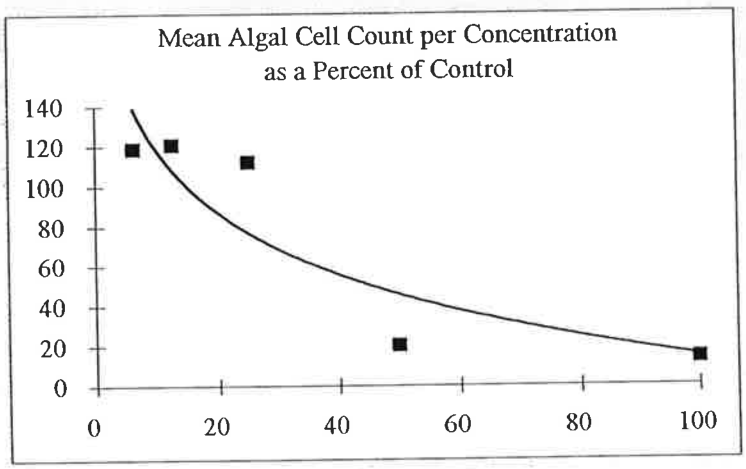
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.
na	not applicable

Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Westmin Resources Ltd. (Myra Falls) Campbell River, Ontario		
Sample:	MF-R-B (M-E-4)		
Sample No.:	9701339-6	**Date Initiated:**	4-Dec-97
Date Sampled:	1-Dec-97	**Time Initiated:**	13:00
		Initiated by:	P. Trainor



TEST DATA

Mean Algal Cell Count Determined by Manual Counts (cells/ml = cell count x 10,000)

replicate	0	6.25	12.5	25	50	100
1	68	84	110	93	13	8
2	67	72	98	68	7	9
3	88	116	74	107	25	15
4	104	115	111	97	21	12
mean / conc.	81.8	96.8	98.3	91.3	16.5	11.0

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	32.7	26.8 - 34.0	Linear Interpolation, (Norberg-King, 1993)	
IC50	40.4	36.8 - 43.1		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9701277-0

CV of control group = 21%

25% concentration used in the IC25/50 calculation.

Reported by: [signature]

Date: Jan. 15/98

Myra Falls.

TEST SPECIFIC CHECKLIST
Test of Larval Growth and Survival Using Fathead Minnows

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
Test Method/Conditions				
Sample preparation				
• Filtering	None(60μm plankton net can be used to remove other small organsims)	✓		
• Temperature	Adjust as required to attain 25±1°C	✓		
• Pre-aeration	If D.O. is ≤40% or ≥100% air saturation in one or more test solutions, all solutions aerated (before fish added) at minimal rate (bubble size 1-3mm) for the lesser of 20 minutes or attaining 40% saturation in the highest test concentration (or 100% in the case of supersaturation)	✓		
• pH Adjustment	No adjustment recommended, however if pH is outside the range for 6.5 to 8.5 then a second (pH adjusted) test should be conducted concurrently	✓		
Test Facility	Maintain good temperature control (25±1°C) extreme fluctuations 23-27°C	✓		
	Isolated from general laboratory disturbances	✓		
	Dust and fumes minimized	✓		
	Construction materials and equipment contacting test-solutions or control/dilution water should not contain any substances that can be leached into the solutions or increase sorption of test material	✓		
	Instruments available to measure basic water quality variables (temp., conductivity, D.O., pH) and lab prepared for other analyses (i.e. hardness, alkalinity, ammonia and residual chlorine, if municipal water) **(Must GM)**	✓		
Test Type	Static renewal (may be flow-through)	✓		
Test Duration	7 days	✓		
Test Temperature	25±1°C, daily mean with extreme fluctuations 23-27°C	✓		
Light Quality	Full spectrum fluorescent	✓		
Light Intensity	≤500 lux at water surface	✓		
Photoperiod	16±1h light; 8±1h dark, gradual transition preferable	✓		
	Photoperiod to coincide with that at which parent fish were held **(Must GM)**	✓		
In-Test pH	No adjustment if pH of test solutions 6.5-8.5	✓		
D.O. Range	40-100% air saturation	✓		
Test Solution Aeration	Normally none, however more frequent renewal of test solutions or gentle aeration if necessary to meet objectives of test	✓		
Test Vessel Size and Type	Beakers, rectangular containers of borosilicate glass, perfluorocarbon plastic or disposable polystyrene, should not restrict surface area of test solution (i.e., diameter of vessel should approximate depth of test solution)	✓		
	Identical for each test solution in a given test	✓		
	Covered during test	✓		
Test Solution Volume	Volume ≥250ml **(Must GM)**, preferably 500ml; water depth ≥3cm	✓		
Renewal of Test Solution	≤24 hours for test duration **(Must GM)**	✓		
	≥80% of solution replaced; dead brine shrimp and detritus removed; new test solution added slowly and cautiously to avoid injury to the fish	✓		
	Each solution mixed well	✓		
Dilution/Control Water	Uncontaminated groundwater, surface water or dechlorinated municipal water; reconstituted water if requiring a high degree of standardization; upstream receiving water to access toxic impact at a specific location; temp. 25±1°C **(Must GM);** D.O 90-100% air saturation at time of use	✓		
	Same water used for preparing control and all test concentrations **(Must GM)**	✓		
	Second control solution should be prepared when water other than that in which fish were cultured is used as dilution/control water			✓
Test Vessel Identification	Each vessel clearly coded or labeled to identify material and concentration being tested, and date & time of test initiation **(Must GM)**	✓		
No. of Test Concentrations	≥5 plus control to calculate ICp and/or NOEC/LOEC **(Must GM)** using appropriate geometric series; one concentration plus control for pass/fail test	✓		
No. of Replicate Vessels/ Concentration	≥3 replicates of each concentration and control **(Must GM)**; (4 recommended).	✓		
	Must achieve randomized assignment of fish to test concentrations **(Must GM)**	✓		
	Test must start with equal number of replicates for each concentration including controls **(Must GM)**	✓		

TEST SPECIFIC CHECKLIST

Test of Larval Growth and Survival Using Fathead Minnows

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
No. of organisms/Test Vessel	≥ 10 fish per test vessel with equal number in each vessel **(Must GM)**	✓		
Organism Distribution	**A)** larvae from different parents or spawnings pooled before assigning larvae to vessels or; **B)** larvae from given spawning divided evenly among all replicates of all concentrations to achieve homogeneity in assigning fish to vessels **(Must RM)**	✓		
	Vessels in random position in water bath **(Must GM)**	✓		
Removal of Dead Organisms	Dead fish discarded	✓		
Feeding Regime	2-3 times/day with newly hatched brine shrimp nauplii (~ 1500-2500 per day) Feed daily during test but not during final 12 hours of test **(Must GM)**	✓		
Test Vessel Cleaning	All test vessels, measurement devices, stirring equipment and fish transfer pails must be throughly cleaned and rinsed in accordance with standard operation procedures **(Must GM)**	✓		
	Control/dilution water used as final rinse		✓	
Substance Testing	Solubilizing agent control solution should be run if used			✓
	Agent concentration ≤0.1 ml/L			✓
Endpoint	NOEC/LOEC and/or ICp for growth and mortality, if appropriate LC_{50} at selected times for multi-concentration tests	✓		
Observations/Measurements				
Temperature	At start and end of 24h periods **(Must GM)**	✓		
D.O.	At start of each 24h period **(Must GM)** and end of each 24h period in representive concentrations	✓		
pH	At start of test in representative vessels before fish are added **(Must GM)**	✓		
	Start and end of each 24h period in representative vessels	✓		
Conductivity	At least at start of 24h periods	✓		
Hardness	Control/dilution water and highest concentration at start of test	✓		
Mortality/Swimming Behaviour	Every 24h **(Must GM)**	✓		
Growth	Mean dry weight at 7.0 days for each vessels **(Must GM)**	✓		
	Fish dried at 100°C for 2-24 hours	✓		
	Scale measures consistently to 10μg	✓		
	Rapid weighing and standard timing among weigh boats **(Must GM)**	✓		
Test Organisms				
Species	*Pimephales promelas*			
Source	Disease-free stock from another laboratory, captured in the wild if special care taken in identifying species and eliminating disease	✓		
Age	Larval fathead minnows hatched for ≤24h **(Must GM)**	✓		
	Test organisms should represent ≥3 spawnings	✓		
	All larval fish must be from the same culture **(Must GM)**	✓		
Health Criteria	Mortalities ≤5% of general population and of fish in individual tanks during 7 days preceding embryo collection; if mortality ≥10% per week special measures taken	✓		
	Groups of diseased fish discarded	✓		
	If fish chemically treated for disease, allow ≥4 weeks before collecting eggs for use in test			✓
	Two dozen pairs of spawning adults should provide ≥200 embryos per day on average and 500 or more per day under good conditions	✓		
Culture/Holding Conditions				
Culture Water	Uncontaminated groundwater, surface water, dechlorinated municipal water or reconstituted water	✓		
	Previously demonstrated to consistently and reliably support good survival, health and growth of fathead minnows	✓		
	TRC ≤0.002mg/L if municipal water used			✓
	Parameters such as residual chlorine (if municipal water used), pH, hardness, alkalinity, TOC, conductivity, suspended solids, D.O., total dissolved gases, temperature, ammonia nitrogen, nitrite, metals and pesticides should be measured as frequently as necessary to document water quality	✓		

TEST SPECIFIC CHECKLIST
Test of Larval Growth and Survival Using Fathead Minnows

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
Culture/Holding Conditions continued	Surface water filtered (≤60μm)			✓
	Acclimation to reconstituted or similar water (if used) for ≥5 days before embryos obtained for test **(Must GM)**	✓		
	Flow to culture aquaria 1.4 L/g fish per day			✓
	Water entering aquaria must not be supersaturated with gases **(Must GM)**		*	✓
	≤0.02mg/L un-ionized ammonia and ≤0.06mg/L nitrite			✓
	Temp., D.O., pH and flow monitored in each tank daily		✓	
	Ammonia, nitrite, TRC (if municipal water) measured weekly			✓
Acclimation	22-26°C for ≥2 weeks before using embryos to obtain larvae for test	✓		
Obtaining Eggs	One spawning substrate per male fish in breeding tanks (i.e. half cylinder of tile or pipe)	✓		
	Daily inspection of tiles mid-morning recommended	✓		
	If embryos, tile should be removed and placed in hatching tray	✓		
	Fish replaced if 3-week period without eggs	✓		
	Automatic replacement of fish on fixed scheduled (e.g. three to six months)		✓	
Hatching Eggs	Aerate tile or remove eggs from tiles and aerate in separatory funnel	✓		
	Inspect incubating embryos daily **(Must GM)**	✓		
	Remove and discard dead embryos or those with fungus	✓		
	Minimal disturbance on days 3-5	✓		
Gene Pool	Larvae for future spawning stock selected from different parents; gene pool should be supplemented every two years	✓		
Facilities and Apparatus	Vessels and accessories contacting organisms and culture media made of non-toxic material **(Must GM)**	✓		
	Culture facility located away from physical disturbances and preferably separate from test containers	✓		
Temperature	Holding 4-26°C	✓		
	Culture 25°C (23-26°C)	✓		
	Rate of change ≤3°C day	✓		
pH	6.0-8.5 (preferably 7.0-8.5)	✓		
D.O.	80-100% in culture aquaria	✓		
	Mild aeration of tanks	✓		
Light Quality	Full spectrum fluorescent	✓		
Light Intensity	≤500 lux at water surface	✓		
Photoperiod	16± 1h light; 8± 1h dark, with gradual transition	✓		
Feeding	Adults: 1 time daily; frozen brine shrimp supplemented by commercial pelleted or flaked food	✓		
	Rate judged by amount consumed in 10 mins. (~1-5% wet body weight)	✓		
	Food stored as recommended by manufacture	✓		
	Newly hatched fish: ≥2 times daily with nauplii of brine shrimp; at 30 days, weaned to frozen brine shrimp	✓		
Cleaning	Siphoning of debris daily or as required	✓		
	Tanks disinfected before introducing new batch of fish	✓		
	Spawning tiles disinfected, scaled and rinsed before reuse (cleaned & rinsed only)		✓	

TEST SPECIFIC CHECKLIST
Test of Larval Growth and Survival Using Fathead Minnows

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
QA/QC				
Test Acceptability Criterion	Invalid if control mortality >20% or if >20% of control fish are moribund or display loss of equilibrium or atypical swimming behaviour **(Must GM)**;	✓		
	Invalid if average final weight of control fish does not attain 250μg when fish dried and weighed immediately after the test or 200μg if fish are first preserved in 70% ethanol **(Must GM)**	✓		
	oxygen in vessels should not fall below 40% saturation	✓		
	Validity questionable if Minimum Significant Difference for average weights of fish, provided by Dunnett's test is >25%			✓
Reference Toxicant Data	At least once each month (with larvae from culture that are used in toxicity tests)	✓		
	Sodium chloride, phenol, zinc sulphate recommended	✓		
Controls	Control/dilution water typical of water used at laboratory	✓		
Sample Handling				
Sample Containers	Containers for transport and storage must be of non-toxic material **(Must GM)**	✓		
	New or thoroughly cleaned and rinsed used containers **(Must GM)**	✓		
Sample Holding Time	Test should begin within 24h and must begin no later than 72h after sampling **(Must GM)**	✓		
Sample Holding Condition	Held at 1-7°C (preferably 4±2°C)	✓		
	If samples ≥7°C, cool to 1-7°C with ice or gal packs			✓
	Samples must not freeze **(Must GM)**	✓		
Sample Volume Required	Samples collected on three discrete occasions, separated by intervals of 2-3 days (i.e. fresh effluent at initial, third and fifth test days) for off-site testing and every 24h for on-site testing		✓	
	4L sample adequate for off-site multiple concentration test;less for single concentration tests			✓
Sample Labeling	Upon collection, sample containers must be completely filled, sealed and labeled or coded **(Must GM)**	1*	✓	
	Label includes at least sample type, source, date and time of collection and name of sample collector(s)		✓	
Subsample Mixing	Samples in collection containers agitated thoroughly just before pouring **(Must GM)**	✓		
	Subsamples (divided between two or more containers) must be mixed together **(Must GM)**	✓		
	Receiving water samples should be filtered (60μm plankton net)	✓	✓ 2*	
REPORTING				
Sample Data	► Sample type	✓		
	► Sample location		✓	
	► Nature, appearance and properties	✓		
	► Volume and/or weight		✓	
	► Information on labeling or coding of test material		✓	
	► Sample collection method		✓	
	► Transport and storage conditions		✓	
	► Person(s) providing/collecting sample		✓	
	► Date and times for sample collection, receipt at test facility and start and end of definitive test	✓		
Test Organisms	► Species and source	✓		
	► Description of culturing and breeding conditions		✓	
	► Weekly % mortalities among fish being grown to maturity and the breeding population		✓	
	► ~% hatching success for embryos being cultured		✓	
	► ~ mortality from hatching to 30 days for larvae being reared		✓	

TEST SPECIFIC CHECKLIST
Test of Larval Growth and Survival Using Fathead Minnows

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
REPORTING Continued				
Test Facilities & Apparatus	▸ Name and address of test laboratory	✓		
	▸ Person(s) performing test	✓		
	▸ Description of system for regulating light and temp. within test facility	✓		
	▸ Description of test vessels	✓		
Control/Dilution	▸ Type(s) and source(s) of control/dilution water	✓		
	▸ Type and quantity of any chemical(s) added to control/dilution water			✓
	▸ Sampling and storage details if dilution water "upstream" receiving water		✓	
	▸ Water pre-treatment	✓		✓
	▸ Measured water-quality variables before and/or at time of commencement of test	✓		
Test Method	▸ Brief mention of method used (if standard)	✓		
	▸ Design and description if specialized procedure or modification of standard method			✓
	▸ Procedure used in preparing stock and/or test solutions of chemicals			✓
	▸ Chemical analyses of test solutions and reference to analytical procedures used			✓
	▸ Use of preliminary or range-finding test			✓
	▸ Frequency and type of observations made during test	✓		
Test Conditions	▸ Number, concentration, depth and volume of test solutions and controls	✓		
	▸ Number of organisms per solution	✓		
	▸ Photoperiod, light source and intensity at surface of test solutions	✓		
	▸ Statement concerning aeration of test solutions prior to and during exposure of fish..	✓		
	▸ Description of any test solutions, pH adjusted or filtered, including procedure			✓
	▸ Any chemical measurements on test solutions	✓		
	▸ Temp., pH, D.O. and conductivity as measured/ monitored in each test solution	✓		
	▸ Total hardness of control/dilution water and the highest test concentration at the start of the test	✓		
Test Results	▸ Conditions and procedures for measuring the NOEC/LOEC and/or ICp for the reference toxicants		✓	
	▸ Appearance of test solutions and changes noted during test	✓		
	▸ Swimming behaviour and number & % of mortality in each solution as noted during each observation period and at the end of the test	✓		
	▸ Number and % of control fish strongly showing a typical swimming behaviour		✓	
	▸ Results for range-finding test (if conducted)			✓
	▸ NOEC/LOEC and/or ICp for growth of larvae and for mortality	✓		
	▸ Minimum Significant Difference in average weights and weight of control fish		✓	
	▸ The statistical test(s) used, and any transformation of data that was required	✓		
	▸ Any LC_{50} (and 95% confidence limits) determined, and the statistical method used for calculation	✓		
	▸ Results of toxicity tests with the reference toxicant(s) for the month of the test, together with the geometric mean value(±2SD) for the same reference toxicant(s) as derived at the test facility in previous tests	✓		

Myra Falls

TEST SPECIFIC CHECKLIST

Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
Test Method/Conditions				
Sample Preparation				
• Filtering	None (60, μm plankton net can be used to remove other small organisms)	✓		
• Temperature	Adjust as required to attain acceptable value (25±1°C)	✓		
• Pre-aeration	If D.O. in one or more tests solutions is <40% or >100% air saturation, all test solutions should be pre-aerated (prior to daphind exposure) for the lesser of 20 minutes or attainment of 40% saturation in the highest test concentration (or100%in the case of supersaturation). Bubble size 1-3mm	✓		
• pH adjustment	No adjustment recommended, however pH adjustment is optional outside 6.0 to 8.5 range, a second (pH adjusted) test might be advisable.	✓		
• Hardness	No adjustment (second adjusted test could be run)	✓		
Test Facilities	Maintain good temperature control (25±1°C)	✓		
	Isolated from physical disturbances that might affect test organisms; test facility isolated from culture area	✓		
	Well- ventilated; dust and fumes minimized	✓		
	Non-toxic and non-leaching construction materials and equipment	✓		
	Instruments available to measure basic water quality variables (temp, conductivity, D.O., pH) and lab prepared for other analysis (i.e. hardness, Alkalinity, ammonia and residual chlorine if municipal water) **(Must GM)**	✓		
Test Type	Static renewal (at least once daily) **(Must GM)**	✓		
Test Duration	Until 60% of control organisms have 3 broods (~7±1days)	✓		
Test Temperature	Daily mean (25±1°C)	✓		
Light Quality	"Cool White" fluorescent	✓		
Light Intensity	≤600 lux at water surface **(Must GM)**	✓		
Photoperiod	16±1h light:8±1h dark; coincides with culture photoperiod **(Must GM)**	✓		
In-Test pH	No adjustment if pH of test solution is between 6.0-8.5	✓		
D.O. Range	40-100% air saturation	✓		
Test Solution Aeration	No aeration during test **(Must GM)** (second aeration test could be run)	✓		
Test Vessel Size and Type	30ml plastic cups, glass beakers or glass test tubes (or vessels ≥ 20ml)	✓		
	Vessels should be covered		✓	
Test Solution Volume	≥15ml, identical volume in each vessel	✓		
Renewal of Test Solution	≤ 24hours for test duration **(Must GM)**	✓		
	First generation daphnids transferred to the respective new solution and live progeny counted, recorded and discarded **(Must GM)**	✓		
	Used solution held for phys/chem measurement	✓		
	Each test solution must be mixed well **(Must GM)**	✓		
Dilution/Control Water	Uncontaminated groundwater, surface water, or dechlorinated municipal water, or reconstituted water; moderately hard reconstituted water if a high degree of standardization is desired; upstream receiving water to assess toxic impact at a specific location; D.O. 90-100% saturation at time of use; hardness within range ±20% of value for culture water	✓		
	Temperature: 25± 1°C, not supersaturated **(Must GM)**	✓		
	Characteristics of water used throughout test period should be uniform	✓		
	Same water used for preparing control and test solutions **(Must GM)**	✓		
	Second control solution should be prepared if water other than that in which organisms have been cultured is used as dilution and control water	✓		
Test Vessel /Identification	Test vessels randomly assigned to a position on a test board using a template or a table of random numbers; if template used, several should be available to avoid the same ordering for each test		✓	
No. of Test Concentrations	≥5 plus control to calculate ICp and/or NOEC/LOEC **(Must GM)** using appropriate geometric series; one test concentration plus control for pass/fail test	✓		
No. of Replicate Vessels/ Concentration	Additional dilutions can be added if high rate of mortality in first 2hrs. of test			✓
	≥10 replicate vessels per test treatment	✓		
	Equal number of replicates among treatments	✓		

TEST SPECIFIC CHECKLIST

Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
No of Organisms /Test Vessel	One neonate per vessel **(Must GM)**	✓		
Organism Distribution	Ten brood cups/beakers, each with ≥8 young used for setting up test	✓		
	One neonate from first brood cup is transferred to each of six test vessels (ie: 5 test solutions, 1 control for 1st replicate)	✓		
	One neonate from second brood cup transferred to 2nd replicate of six test vessels etc.	✓		
Feeding Regime	Daily, with 0.1ml YCT and 0.1ml algal suspension (or suitable alternate diet) added to each test vessel **(Must GM)** 0.5 mL	✓		
	Food type and ration identical to that provided for individual cultures	✓		
Test Vessel Cleaning	All test vessels, measurement and stirring devices and daphnid transfer apparatus must be thoroughly cleaned and rinsed in accordance with good laboratory procedure **(Must GM)**	✓		
	Control /dilution water should be used in final rinse		✓	
Substance Testing	Solubilizing agent control solution should be run, if used			✓
	Agent concentration should not exceed 0.1ml/L			✓
Endpoint	Mortality and reproduction; NOEC/LOEC and /or ICp for multi-concentration tests; if appropriate, LC_{50} at selected time	✓		
Observations/Measurements				
Temp. D.O. + pH	At least at beginning and end (before renewal)of each 24-hour exposure in representative concentrations **(Must GM)**	✓		
	Temperature must be monitored throughout test **(Must GM)**	✓		
	If temperature records based on measurement other than in test vessels, the relationship between readings and temperatures within vessels must be established **(Must GM)**			✓
Conductivity	Recommend daily measurement of each newly - prepared test solution (prior to dispensing new solutions)	✓		
Hardness	Control and highest test concentration, at least before starting test	✓		
Mortality	Daily (magnifying device recommended)**(Must GM)**	✓		
	Death of any first generation daphnid recorded **(Must GM)**	✓		
Reproduction	Daily observation of number of live neonates produced by each 1st generation daphnid **(Must GM)**	✓		
	Counting of dead neonates not required	✓		
Test Organisms				
Source	Commercial biological supply house or government laboratory; taxonomy ideally verified by microscopic examination	✓		
	All organisms used in a test must be from the same culture **(Must GM)**	✓		
Age	Neonates (≤24hr. old); all within 8h of the same age **(Must GM)**	✓		
	Neonates taken from individual cultures	✓		
Health Criteria	Individual brood cultures should have ≤20% mortality of brood organisms and must have an average of ≥15 young produced during week before test **(Must GM),** with ≥6 young produced by a brood organism in previous brood	✓		
	No ephippa produced in culture **(Must GM)**	✓		
Culture/Holding Conditions				
Culture Water	Uncontaminated groundwater, surface water, dechlorinated municipal water or reconstituted water; water should consistently support good survival, growth and reproduction daphnids	✓		
	Each batch of culture water should not be held for more than 14 days	✓		
	TRC ≤0.002mg/L if municipal water used			✓
	Parameters such as hardness, alkalinity, residual chlorine (if municipal water), pH, total organic carbon, SS., D.O., total dissolved gases, temp, ammonia nitrogen, nitrite, metals and pesticides should be measured in water as frequently as necessary to document water quality	✓		
Acclimation	Culture started ≥3 weeks before brood animals needed	✓		
Mass Cultures	Established and maintained to ensure supply of neonates for individual cultures	✓		
Individual Cultures	Neonates from mass cultures not to be used in tests **(Must GM)**	✓		
	Cultures from a single brood organism to provide test organisms **(Must GM)**	✓		
	Young produced from first 2 broods are discarded	✓		
	Young produced from 3rd and subsequent broods used for toxicity tests provided that adults are ≤ 14 days old	✓		

TEST SPECIFIC CHECKLIST
Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
Facilities and Apparatus	Daphnids cultured under controlled-temperature conditions **(Must GM)**	✓		
	Culture facility isolated from test facility, solution preparation/storage and equipment cleaning areas	✓		
	Materials of vessels and accessories contacting organisms and culture media must be nontoxic **(Must GM)**	✓		
	Materials such as copper, brass, galvanized metal, lead and natural rubber must not come in contact with culture vessels or media, test samples, test vessels, dilution water or test solutions **(Must GM)**	✓		
	New glass beakers used as culture or test vessels must be cleaned and acid-soaked before use **(Must GM)**	✓		
	Culture vessels covered	✓		
Temperature	25±1°C	✓		
	Rate of change ≤ 3°C /day	✓		
pH	6.0-8.5 (7.0-8.5 preferred)	✓		
D.O.	Culture water aerated before use as required to provide 90-100% saturation	✓		
	Cultures not aerated	✓		
	Not supersaturated **(Must GM)**	✓		
Hardness	Within range of ± 20% of that of control/dilution water for ≥ 2 generations of daphnids preceding test organisms	✓		
Light Quality	"Cool White" fluorescent	✓		
Light Intensity	≤600 lux at water surface **(Must GM)**	✓		
Photoperiod	16±1h light; 8±1h dark	✓		
Handling	Minimal, by pipetting	✓		
Feeding	Daily **(Must GM)**; yeast, Cerophyll ™ and trout chow (YCT) plus algae	✓		
	Food added to fresh culture median immediately before or after transfer of organisms	✓		
	Algal concentrate and YCT throughly mixed by shaking before dispensing **(Must GM)**	✓		
	Thawed YCT stored in refrigerator and unused portions discarded after 2 weeks **(Must GM)**	✓		
	Unused algal concentrate stored in fridge and discarded after 1 month **(Must GM)**	✓		
Cleaning	Water replaced ≥2(for mass culture) or≥3(individual culture) times per week	✓		
QA/QC				
Test Acceptability Criteria	Invalid if control mortality of first generation adults is≥ 20% and/or if an average of < 15 live young produced per surviving female in the control solutions (at the point where 60% of control organisms have had 3 broods) **(Must GM)**	✓		
	Also invalid if ≥60% of first generation adults in control solutions have not produced three broods by day 9 at 25±1°C **(Must GM)**	✓		
Reference Toxicant Data	Within 14 days of definitive test (ideally using same stock of brood animals)	✓	✓1*	
	Standard test for NOEC / LOEC and/or ICp	✓		
Controls	Sodium chloride, phenol or zinc sulphate recommended	✓		
	Using same water as culture/dilution water	✓		
Sample Handling				
Sample Containers	Containers for transportion and storage must be of non-toxic material **(Must GM)**	✓		
	New or thoroughly cleaned and rinsed used containers **(Must GM)**	✓		
Sample Holding Time	Test should begin within 24h and must commence no later than 72h after sampling **(Must GM)**	✓	✓2*	
Sample Holding Conditions	Held at 1-7°C (preferably 4±2°C)	✓		
	If samples ≥7°C, cool to 1-7°C ice or gel packs			✓
	Samples must not freeze **(Must GM)**	✓		
Sample Volume Required	Samples collected on three discrete occasions separated by intervals of 2-3 days (fresh effluent first, third and fifth test days) for off-site testing and every 24h for on-site testing		✓	
	2L sample adequate for off-site multiple concentration test; less for single-concentration tests			✓
Sample Labelling	Upon collection, sample containers must be completely filled, sealed and labeled or coded **(Must GM)**		✓3*	
	Included at least sample type, source, date and time of collection and name of sample collectors		✓	
	Samples in collection containers agitated thoroughly just before pouring **(Must GM)**	✓		
Subsample Mixing	Sub-samples (divided between two or more containers) must be mixed together **(Must GM)**	✓		
	Receiving water samples should be filtered (60μm plankton net)	✓		

all except 9700633-2

TEST SPECIFIC CHECKLIST

Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*

Prepared: April 1996

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
REPORTING:				
Sample Data	▸ Sample type	✓		
	▸ Sampling location		✓	
	▸ Sampling method and schedule		✓	
	▸ Nature, appearance and properties	✓		
	▸ Information on labeling or coding of test material		✓	
	▸ Transport and storage conditions		✓	
	▸ Person(s) providing/collecting sample		✓	
	▸ Date and time for sample collection, receipt at test facility and start and end of definitive test ... except receipt	✓		
Test Organisms	▸ Species and source	✓		
	▸ Description of culturing conditions	✓		
	▸ Estimated % mortality in individual cultures during 7 days preceding test		✓	
	▸ Average number of surviving young produced per adult in individual cultures during 7 days preceding test		✓	
	▸ Number of young produced by brood organism in previous brood		✓	
	▸ Observation of ephippia in culture			✓
	▸ Age of test organisms at beginning of test	✓		
Test Facilities	▸ Name and address of test laboratory	✓		
	▸ Person(s) performing test	✓		
	▸ Description of system for regulating light and temperature within test facility	✓		
	▸ Description of test vessels and covers	✓		
	▸ Description of procedures used to clean or rinse apparatus		✓	
Control/Dilution Water	▸ Type(s) and source(s) of control/dilution water	✓		
	▸ Type and quantity of any chemical(s) added to control/dilution water			✓
	▸ Water sampling, pre-treatment and storage details			✓
	▸ Measured water quality variables before and/or at time of test commencement	✓		
Test Method	▸ Indication of method used (if standard)	✓		
	▸ Design and description if specialized procedure or modification of standard method			✓
	▸ Procedure used in preparing stock and/or test solutions of chemicals			✓
	▸ Chemical analyses of test solutions and reference to analytical procedures used			✓
	▸ Use of preliminary or range-finding test		✓	
	▸ Frequency and type of oberservations made during test	✓		
Test Conditions	▸ Number, concentration, depth (no) and volume of each replicate test solution and controls	✓		
	▸ Number of organisms per test solution and per 15ml volume	✓		
	▸ Photoperiod, light source and intensity at surface of test solutions	✓		
	▸ Statement concerning aeration of test solutions prior to daphnid exposure	✓		
	▸ Description of any test solutions adjusted for pH or hardness, including procedure and timing			✓
	▸ Description of source and type of food used during test and feeding method frequency and ration ... type & source = yes		✓	
	▸ Conditions and procedures for preparing reference toxicant solutions and for performing test and determine NOEC/LOEC and/or ICp	✓		
	▸ Any chemical measurements on test solution	✓		
	▸ Temperature, pH, D.O. and conductivity as monitored in each test solution	✓		
	▸ Total hardness of control/dilution water and the highest test concentration at the start of test	✓		

TEST SPECIFIC CHECKLIST

Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*

Prepared: May 1995

PARAMETER	SPECIFICATION	SPECIFICS MET? ✓ Y	N	NA
Test Results	▸ Appearance of test solutions and changes noted during test	✓		
	▸ % mortality and number of neonates per first-generation daphnid in each test solution (plus controls) as noted during each observation period	✓		
	▸ Results for range-finding test (if conducted)			✓
	▸ NOEC/LOEC and/or ICp for mortality and reproductive success of first-generation daphnids and the statistical test(s) used	✓		
	▸ Minimum significant % change from the control data that could be detected in the test		✓	
	▸ Any transformation of data that was required	✓		
	▸ Any LC50 (and 95% confidence limits) determined and statisical method used	✓		
	▸ Results for reference toxicant tests performed within 14 days of test, with geometric mean value (±2SD) for the same reference toxicant(s) as derived at the test facility in previous tests.	✓		

REPORT ASSESSMENT CHECKLIST FOR GROWTH INHIBITION TEST USING THE FRESHWATER ALGA *Selenastrum capricornutum*

Myra Falls.

A/ Sample Identification Data PLEASE COMPLETE THE FOLLOWING SECTION

1) Facility Name/Location: Beak - Brampton
2) Lab Name/Location: ✓ 3) Sample Point: ______
4) Sampling Date & Time: ______ 5) Type of Sample: ______

B/Required and Recommended Reporting and Method Conditions

PLEASE READ THE FOLLOWING INSTRUCTIONS PRIOR TO COMPLETING THE REPORT ASSESSMENT TABLE

- Column one of the table lists reporting and method requirements or recommendations. Reporting items are specified in regular type, and method requirements are indicated in bold type and bracketed, e.g.(**bold**).
- In column two of the table, mark under the Y if data have been reported, or under the N if data have not been provided.
- If data meet the method "must" requirements specified, mark under the Y in the third table column; if the method "must" requirements specified are not met, indicate under the N. Reported items which have no associated method "must" requirements have been hard-coded with an X in the "Not Applicable" (NA) column.

REPORTING AND METHOD ITEMS	Have Data Been Reported?		Have Required Method Conditions Been Met?		
REQUIRED REPORTING FOR EFFLUENT[a]	Y	N	Y	N	NA
Effluent Data					
• sampling method (e.g. equipment used, grab, composite)	....	✓			X
• sample collection dates	✓	....			X
• test initiation date and time (**must commence ≤3 days after sampling**)	✓	....	✓	....	
Observations					
• any unusual observations made during the test (e.g., concentration-response, formation of precipitate, pH, oxygen, conductivity)	✓	....			X
Results					
• cell concentration in control and test concentration replicates, and mean cell concentration of control and individual test concentrations with corresponding coefficient of variation as noted during each observation period (**test is invalid if number of algal cells in the standard controls have increased by a factor of <16 in 72 hours and/or cell yield estimates in the standard control wells are not homogeneous (C.V. > 20%); if enhancement growth occurs (growth in test wells > growth in control wells), these values cannot be included in the calculation of the IC50 but should be reported**)	✓	....	N cv for conc. ✓	....	
• NOEC, LOEC, TEC, IC50 and 95% confidence limits, IC25 and 95% confidence limits for algal growth; the statistical methods used and any data transformations applied	✓	....	N, NOEC/LOEC or TEC		X
• results for Quality Control Microplate (**a Quality Control Microplate must be incubated with every algal growth inhibition test; test is invalid if algal growth in standard controls differs significantly (p > 0.05) from that in the Quality Control Microplate**)	✓ 1*	....	✓	....	
Reference Toxicant Data					
• most recent NOEC or ICp for reference toxicant (recommend that the result fall within the warning limits (± 2 SD) of the historic reference toxicant mean)	✓	....			X
• date reference toxicant test initiated (recommend that reference toxicant test is conducted at least once each month with Reagent water routinely used in algal toxicity tests)	✓	....			X
• historical geometric mean, warning limits (mean ± 2 SD), and control limits (mean ± 3 SD) ... no mean ...	✓	....			X
RECOMMENDED REPORTING FOR EFFLUENT[b,c]					
Effluent Data					
• sample type (e.g., whole effluent, final effluent, receiving water)	✓	....			X
• brief description of sampling point	....	✓			X
• sample transport and storage conditions	....	✓			X
Test Facilities and Conditions					
• test method (**EPS 1/RM/25**) and type (**static; 72 hour**) ... method only ...	✓	....	✓ 2*	....	
• species and source(i.e., strain number, origin, etc.) of test organism(***Selenastrum capricornutum*; algal culture is 4 - 7 days old and in a logarithmic growth phase**)	✓ 3*	✓	✓	....	
• person performing test and verifying results (e.g. signing report)	✓	....			X
• Environmental Conditions					
♦ test temperature (**24 ± 2°C**)	✓	....	✓ 4	....	
♦ light quality (**overhead "cool white" fluorescent**)	....	✓	✓ *	....	
♦ light intensity (**4 ± 10% klux at surface**;recommend quantal flux of 60 - 80 μE/(m² . s))	✓	....	✓	....	
♦ photoperiod (**continuous light**)	✓	....	✓ *4	....	
♦ aeration (recommend none)	✓	....			X
♦ pH adjustment (recommend no pH adjustment if test solution pH is 6 - 9)	✓	....			X
♦ filtration (**5 -10mL subsample filtered through preconditioned 0.45μm pore diameter membrane**) Stated, except for 9700158 - it but was filtered	✓	....	✓	....	
♦ test solution volume (**final test volume 220μL;≥3mL for each sample concentration**)	✓	....	✓	....	
• type(s) and source(s) of control/dilution water (**same water used for preparing control and test solutions**)	✓	....	✓	....	
• number and concentration of test solutions (recommend 10 concentrations plus a sample control (control/dilution water and a standard control (reagent water), except when reagent water is used as control/dilution water)	✓	....			X
• number of replicates per concentration (**≥3 replicates for each concentration including controls**; 4 recommended)	✓	....	✓	....	
• number of algal cells per test vessel (recommend 2200 cells per well or 10,000 cells per mL; recommend algal inoculum ≈ 220,000 cells/mL)	✓	....			X
• Culture Health					
♦ indication of whether health criteria are met					
• (**alga uncontaminated with other species of algae or microorganisms**)	....	✓	✓ 5*	....	
• (**alga in exponential growth phase**)	✓	**6 ✓	✓	....	
• (recommend routine assessment of health using growth curves at various initial inoculum concentrations, performed monthly)	....	✓			X
• Observations and Physical/Chemical Characteristics of Sample Dilutions and Controls					
♦ temperature (recommend measurement in incubator or chamber)	✓	....			X
♦ pH (**measured at start of test and at test end; test is invalid if pH in controls vary by more than 1.5 pH units**) ... Start only ...	✓	....	....	....	
Results					
• results for range-finding test (if conducted)	....	✓			X
• chemical(s) used for reference toxicant testing	✓	....			X

Note: See footnotes on reverse side of sheet.

study ranged from 11.8-19.2 in APHA medium and 11.6-21.6 in receiving waters. All tests were therefore valid. In only one case, E51 (Heath Steel 11/12/97) was the control in receiving water slightly lower than that in APHA; the test was still valid.

3.2 Control growth

Growth of *Lemna minor* may be expressed as either biomass (fronds at 7 d) or as growth rate (k). Traditionally, results of *Lemna* tests have been calculated on the basis of biomass but for comparison with phytoplankton tests growth rate may be more relevant. Calculations made on the basis of growth rate will also allow comparison of tests of different duration. For the nine CANMET tests, growth of controls (in artificial inorganic medium (APHA), and receiving water is shown in Table 2, expressed as biomass and growth rate.

Table 2 Control growth in APHA and receiving water expressed as biomass and growth rate

Site	#	Collection date	Controls as biomass (fronds/7d)		Control as growth rate (k*)	
			APHA	receiving water	APHA	receiving water
Heath Steel Mine Newcastle, NB	E44	06/24/97	45.8	46.1	0.387	.390
	E48	08/28/97	54.6	63.0	0.413	.434
	E51	11/12/97	44.0	34.8	0.383	0.349
Placer Dome Mine South Porcupine, ON	E45	07/02/97	37.3	45.9	0.358	0.389
	E46	07/29/97	35.3	39.0	0.350	0.369
	E50	10/20/97	48.1	54.2	0.396	0.421
Myra Falls Effluent Campbell River, BC	E47	08/13/97	57.6	64.7	0.420	0.436
	E49	09/30/97	43.9	53.4	0.382	0.411
	E52	12/02/97	51.5	53.6	0.405	0.411

*k=Growth rate = log (A/B)*2.30259/7, where A = fronds at seven days and B = initial fronds

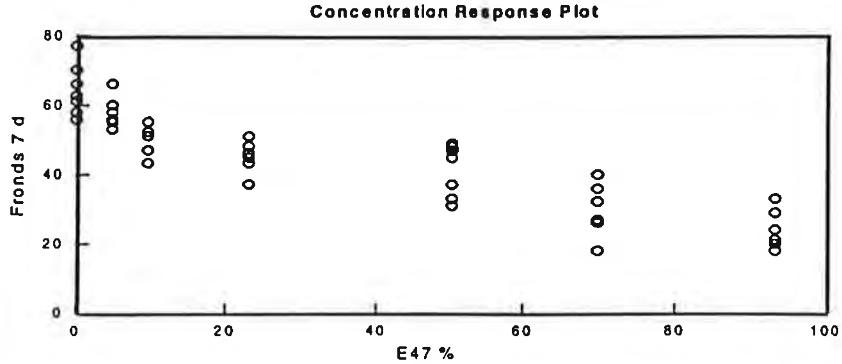
Quality control charts comparing control performance expressed as biomass (fronds at 7d) and growth rate (k) are shown in Fig. 1. Data for each experiment is plotted against historical data collected from 07/03/95 to the test date. A running mean and 95% confidence limits are plotted. These charts provides a visual means of monitoring culture health and test conditions. A series of tests such as those from 27/03/96 to 19/06/96 which fall slightly below the mean growth rate suggest that though the conditions were stable and the tests valid a potential problem was indicated. In fact, light conditions in the growth chamber had changed slightly; when the condition was corrected control growth responded strongly. The expected pattern of variability on either side of the mean was restored. When expressed as biomass, mean control biomass of accumulated historical data is 48 with 95 % confidence limits of 22-74. Data for the nine CANMET tests ranged from 37-58 with a mean of 46. Mean control growth rate of accumulated historical data is 0.392 with 95 % confidence limits of 0.317-0.467. Data for the nine CANMET tests ranged from 0.350 to 0.450 with a mean of 0.388.

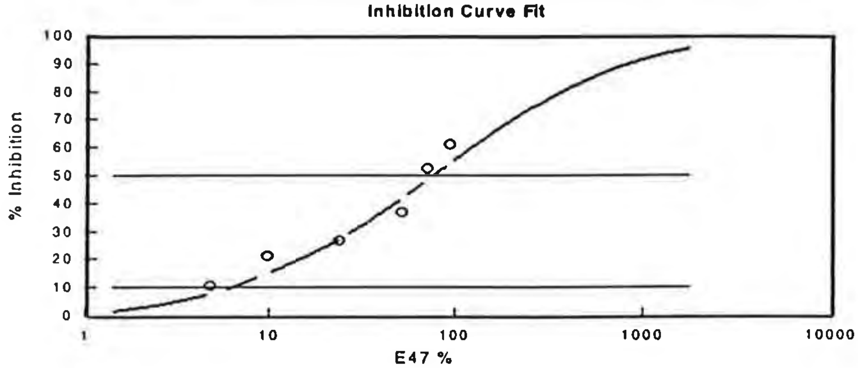
Lemna minor

MM456
Control growth rate 63.625
Stanadard deviation 7.1

Estimated IC values

	IC E47 %	95% Confidence limits	
IC10	5.8	1.5	22.3
IC20	13.8	4.9	38.7
IC25	19.2	7.9	46.8
IC50	72.8	49.0	93.1





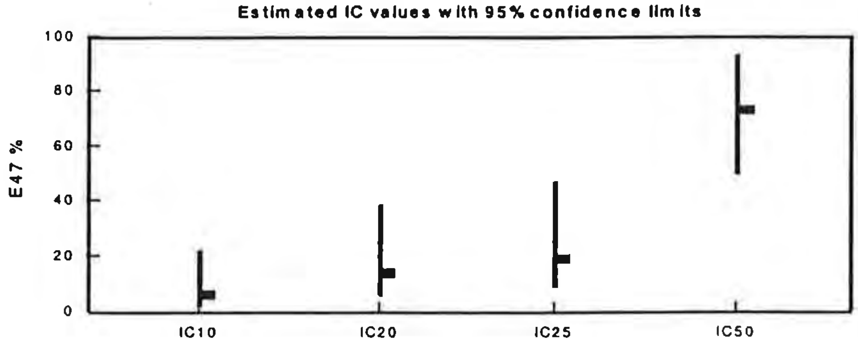


Figure 9 **Concentration response plot, inhibition curve fit and estimated IC values with 95% confidence limits for *Lemna minor* toxicity test: E47 Myra Falls mine effluent (July 13/97)**

L. minor

MM456

Estimated IC values

	IC E49 %	95% Confidence limits	
IC10	50.0	39.8	62.9
IC20	62.4	53.7	72.4
IC25	67.4	59.5	76.3
IC50	89.1	80.7	93.1

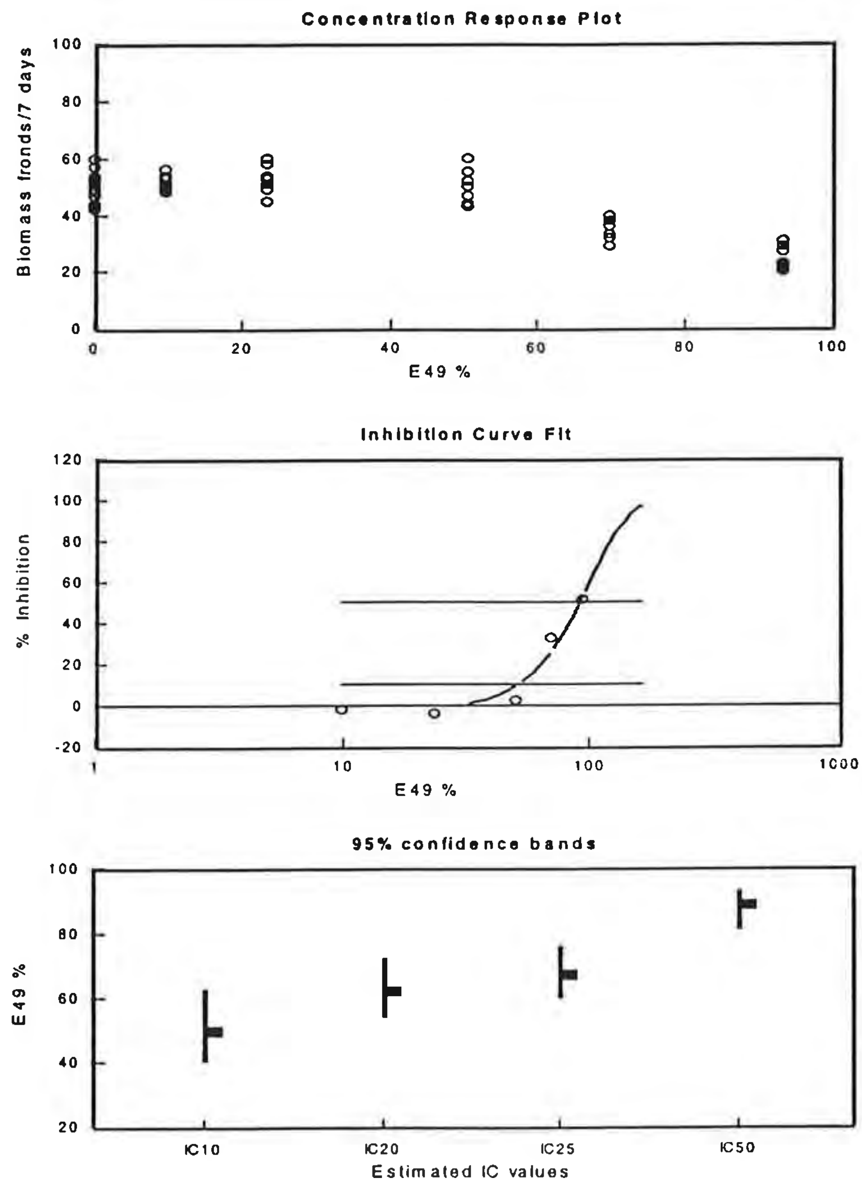


Figure 10 **Concentration response plot, inhibition curve fit and estimated IC values with 95% confidence limits for *Lemna minor* toxicity test: E49 Myra Falls mine effluent (Sept. 30/97)**

L. minor

MM456

Estimated IC values

	IC E52 %	95% Confidence limits	
IC10	23.2	13.7	39.3
IC20	37.9	26.7	53.9
IC25	45.6	34.4	60.4
IC50	92.5	76.0	93.1

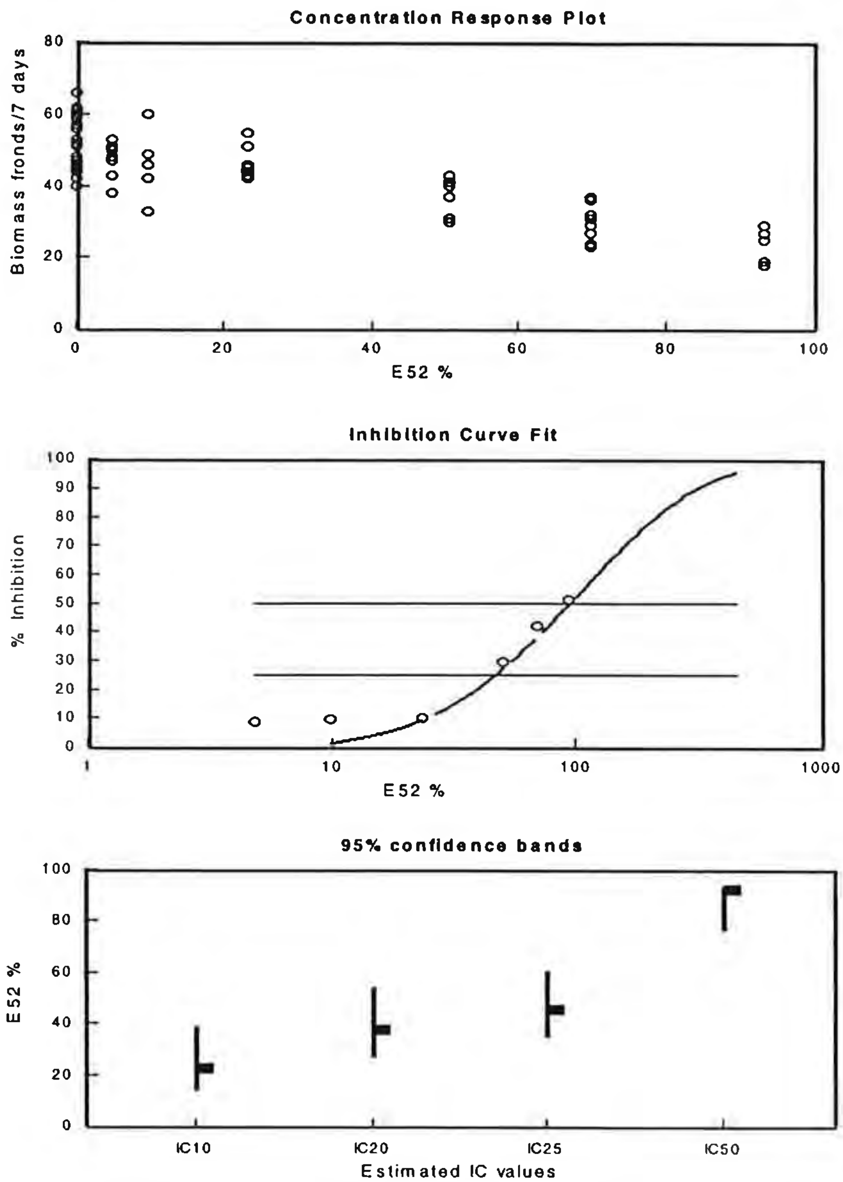


Figure 11 **Concentration response plot, inhibition curve fit and estimated IC values with 95% confidence limits for *Lemna minor* toxicity test: E52 Myra Falls mine effluent (Dec. 2/97)**

Test identification	
Date of test	Aug 14/97
Technologist	Mary Moody
File	MM456
Effluent identification	
SRC #	E47
Sample identity	Myra Falls Effluent
Location	Campbell River, B.C.
Date of collection	Aug 13/97
Receiving water identification	
SRC #	RW47
Location	Myra Falls
Date of collection	July 21/97
***Lemna minor* QA/QC results**	
mean control growth rate in synthetic medium	0.42
95% confidence limits*	0.400 - 0.440
Reference toxicant:	Cr 1 mg/L
mean % inhibition of biomass by reference toxicant	71
95% confidence limits*	64 - 78
Mean increase in control leaves (8 for a valid test)	
♦ in synthetic medium (x)	19.2
♦ in receiving water (x)	21.6
Lemna minor* test results*	
Test diluent	receiving water (RW47)
IC_{25} (%v/v)	19.2
95% confidence limits	7.9 - 46.8
IC_{50} (%v/v)	72.8
95% confidence limits	49.0 - 93.1

* calculated by Sigmaplot v 4.0

** calculated according to Nyholm *et al.*, 1992 and Andersen *et al.* 1995 (referenced in *L. minor* method)

Test validity criteria with regard to test environment, control growth rate and leaf increase, absence of algae and *Lemna* culture are met.

Test identification	
Date of test	Dec. 3, 1997
Technologist	Mary Moody
File	MM456
Effluent identification	
SRC #	E52
Sample identity	Myra Falls effluent
Location	Campbell River, B.C.
Date of collection	Dec. 2/97
Receiving water identification	
SRC #	RW52
Location	Myra Falls
Date of collection	unknown, forwarded from Beak
***Lemna minor* QA/QC results**	
mean control growth rate in synthetic medium	0.405
95% confidence limits*	0.386-0.423
Reference toxicant:	Cr 1 mg/L
mean % inhibition of biomass by reference toxicant	77
95% confidence limits*	74-80
Mean increase in control leaves (8 for a valid test)	
♦ in synthetic medium (x)	17.2
♦ in receiving water (x)	17.9
Lemna minor* test results*	
Test diluent	receiving water (RW 52)
IC_{25} (%v/v)	45.6
95% confidence limits	34.4-60.4
IC_{50} (%v/v)	92.5
95% confidence limits	76-93.1

* calculated by Sigmaplot v 4.0
** calculated according to Nyholm *et al.*, 1992 and Andersen *et al.* 1995 (referenced in *L. minor* method)

Test validity criteria with regard to test environment, control growth rate and leaf increase, absence of algae and *Lemna* culture are met.

Sample Identification: E49 Myra Falls effluent, collected Sept.30/97
Receiving water (RW), forwarded from Beak
Test date: Oct 2-8/97
Reference Toxicant: K_2CrO_4 (as Cr 1 mg/L)

Raw Data

Concentration	Frond Counts at 7 d								Lemna Condition 7 d
Control in APHA	35	51	42	46	50	37	45	45	healthy
Ref. Toxicant Cr 1 mg/L	11	10	12	12	12	10	11	12	yellow green
Control in RW	52	54	60	53	53	51	51	52	healthy
0.097%	52	43	43	52	44	51	42	51	healthy
0.485%	42	49	57	43	47	53	47	51	healthy
0.97%	48	54	57	60	49	53	60	49	healthy
2.425%	47	60	50	49	55	49	40	48	healthy
4.85%	48	52	47	49	54	55	51	51	healthy
9.7%	53	49	54	56	51	48	50	53	healthy
23.28%	53	51	58	60	49	45	54	53	healthy
50.44%	44	44	47	60	52	43	55	50	slightly pale
69.84%	38	40	33	32	36	32	29	33	slightly pale
93.12%	22	27	23	23	21	29	31	20	yellow green

pH at 7 days										mean
APHA	Control	8.64	8.91	8.88	8.99	9.02	8.68	8.95	8.83	8.86
RW	Control	8.93	8.97	8.27	8.42	8.26	8.75	8.78	8.64	8.63
E49	0.097%	8.51	8.57	8.65	8.79	8.84	8.68	9.36	9.01	8.80
E49	93.12%	8.38	8.44	8.46	8.48	8.40	8.45	8.52	8.58	8.46

Quality Control Data (95% confidence limits in parenthesis)

mean control growth rate in APHA medium	0.382 (0.366-0.398)
mean % inhibition by reference toxicant (Cr 1 mg/L)	80 (78-82)
mean control frond increase in APHA medium (x)	14.6
mean control frond increase in receiving water (x)	17.8

Sample Identification: E52, Myra Falls effluent, collected Dec 2/97
Receiving water (RW), forwarded from Beak
Test date: Dec 3-10/97
Reference Toxicant: K_2CrO_4 (as Cr 1 mg/L)

Raw Data

Concentration	Frond Counts at 7 d								Lemna Condition 7 d
Control in APHA	64	49	47	45	61	47	41	58	healthy
Ref. Toxicant Cr 1 mg/L	15	18	12	13	14	13	13	15	yellow green
Control in RW	56	48	48	62	51	45	53	66	healthy
0.097%	46	61	48	57	52	59	60	47	healthy
0.485%	44	45	52	57	40	53	42	47	healthy
0.97%	50	42	66	41	45	50	45	51	healthy
2.425%	47	41	48	48	35	56	47	43	healthy
4.85%	38	48	43	53	51	48	47	50	healthy
9.7%	49	49	33	46	60	42	49	46	healthy
23.28%	43	46	55	44	45	45	51	42	healthy
50.44%	41	40	30	37	43	40	30	31	pale green
69.84%	36	27	37	31	32	24	29	23	pale green
93.12%	29	27	29	19	25	18	25	29	yellow green

pH at 7 days										mean
APHA	Control	9.16	9.25	9.21	9.03	9.08	9.13	9.12	9.24	9.15
RW	Control	9.34	9.34	9.31	9.26	9.24	9.27	9.25	9.07	9.26
E52	0.097%	9.11	9.12	9.14	9.22	9.35	9.21	9.22	9.18	9.19
E52	93.12%	8.57	8.37	8.43	8.43	8.50	8.38	8.51	8.50	8.46

Quality Control Data (95% confidence limits in parenthesis)

mean control growth rate in APHA medium	0.405 (0.386-0.423)
mean % inhibition by reference toxicant (Cr 1 mg/L)	77 (74-80)
mean control frond increase in APHA medium (x)	17.2
mean control frond increase in receiving water (x)	17.9

Sample Identification: E52, Myra Falls effluent, collected Dec 2/97
Receiving water (RW), forwarded from Beak
Test date: Dec 3-10/97
Reference Toxicant: K_2CrO_4 (as Cr 1 mg/L)

Raw Data

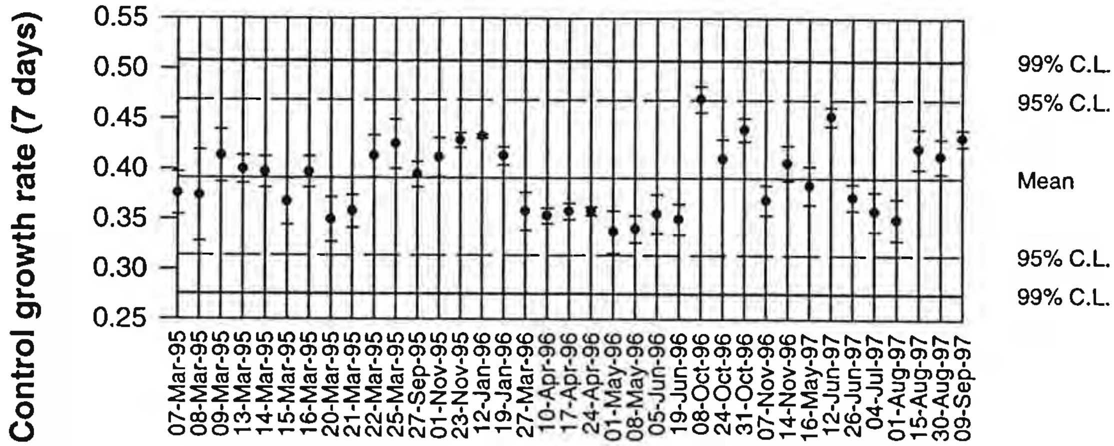
Concentration	Frond Counts at 7 d								Lemna Condition 7 d
Control in APHA	64	49	47	45	61	47	41	58	healthy
Ref. Toxicant Cr 1 mg/L	15	18	12	13	14	13	13	15	yellow green
Control in RW	56	48	48	62	51	45	53	66	healthy
0.097%	46	61	48	57	52	59	60	47	healthy
0.485%	44	45	52	57	40	53	42	47	healthy
0.97%	50	42	66	41	45	50	45	51	healthy
2.425%	47	41	48	48	35	56	47	43	healthy
4.85%	38	48	43	53	51	48	47	50	healthy
9.7%	49	49	33	46	60	42	49	46	healthy
23.28%	43	46	55	44	45	45	51	42	healthy
50.44%	41	40	30	37	43	40	30	31	pale green
69.84%	36	27	37	31	32	24	29	23	pale green
93.12%	29	27	29	19	25	18	25	29	yellow green

pH at 7 days										mean
APHA	Control	9.16	9.25	9.21	9.03	9.08	9.13	9.12	9.24	9.15
RW	Control	9.34	9.34	9.31	9.26	9.24	9.27	9.25	9.07	9.26
E52	0.097%	9.11	9.12	9.14	9.22	9.35	9.21	9.22	9.18	9.19
E52	93.12%	8.57	8.37	8.43	8.43	8.50	8.38	8.51	8.50	8.46

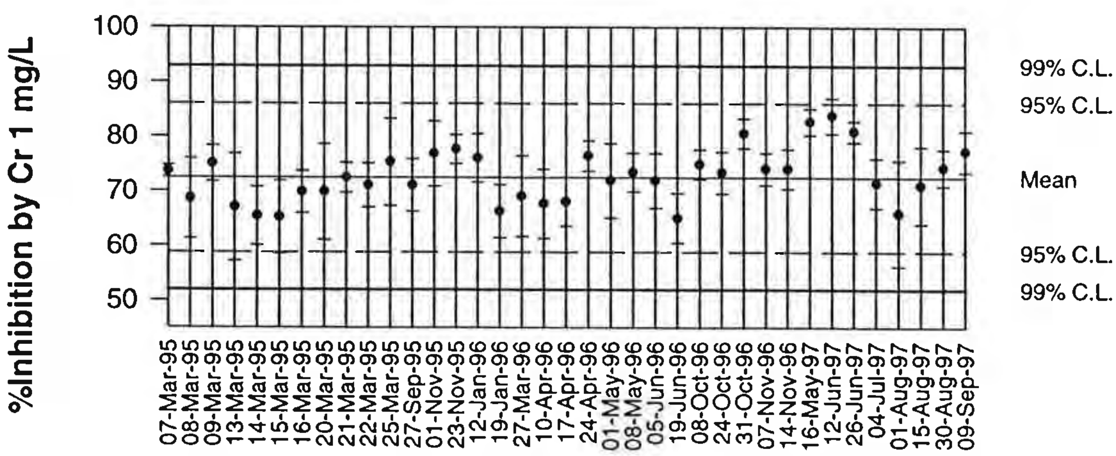
Quality Control Data (95% confidence limits in parenthesis)

mean control growth rate in APHA medium	0.405 (0.386-0.423)
mean % inhibition by reference toxicant (Cr 1 mg/L)	77 (74-80)
mean control frond increase in APHA medium (x)	17.2
mean control frond increase in receiving water (x)	17.9

Lemna minor Control Charts 1995-1997



Control 7 days growth rate (doublings/24 h) of Lemna minor for experiments from March 1995 to Sept 1997. Mean and 95% confidence limits for each experiment and cumulative mean, 95 and 99% control limits are shown (broken line 95%, solid line 99%)



Percent inhibition of biomass of Lemna minor for reference toxicant tests from March 1995 to Sept 1997. Mean and 95% confidence limits for each experiment and cumulative mean, 95 and 99% control limits are shown.

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MR1-S	0351CRSD	62 ± 4	7	0.67* ± 0.08	13	4 Oct.
MR2-S	0352CRSD	52* ± 4	9	0.66* ± 0.05	7	4 Oct.
MR3-S	0353CRSD	58* ± 4	8	0.64* ± 0.08	12	4 Oct.
MR4-S	0354CRSD	84 ± 15	18	0.76 ± 0.28	37	4 Oct.
MR5-S	0355CRSD	58* ± 8	14	0.57* ± 0.09	16	23 Oct.
MR6-S	0356CRSD	28*± 4	16	0.56* ± 0.04	7	4 Oct.
MR7-S	0357CRSD	72 ± 8	12	0.73 ± 0.36	49	4 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.
*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student Test).
The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.
19-jan-98

Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

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CERTIFICATE OF ANALYSIS

Client:	BEAK (Brampton)
Adresse:	14 Abacus rd Brampton, On L6T 5B7
Contact:	D. Farara/P. McKee
Project N° :	20776.230
Type of sample:	Sediment
Collected by:	BEAK (Brampton)
Method of transport:	Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MF1-S	0442CRSD	64* ± 6	9	1.24 ± 0.18	14	22 Oct.
MF2-S	0443CRSD	60* ± 10	17	1.13 ± 0.16	14	22 Oct.
MF3-S	0444CRSD	68 ± 4	7	1.06 ± 0.12	12	22 Oct.
MF4-S	0445CRSD	62* ± 4	7	1.11 ± 0.16	14	22 Oct.
MF5-S	0446CRSD	54* ± 6	10	1.09 ± 0.17	15	22 Oct.
MF6-S	0447CRSD	60 ± 19	31	1.05 ± 0.18	17	22 Oct.
MF7-S	0448CRSD	52* ± 8	16	1.31 ± 0.24	18	22 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

19-jan-98

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MN4-S	0449CRSD	0*	--	--	--	4 Oct.
MN5-S	0450CRSD	0*	--	—	–	23 Oct.
MN6-S	0451CRSD	0*	--	—	--	23 Oct.
MN7-S	0452CRSD	2* ± 4	224	0.49[4]	--	23 Oct.
MN8-S	0453CRSD	0*	--	—	--	23 Oct.
MN9-S	0454CRSD	2* ± 4	224	0.50[4]	--	23 Oct.
MN10-S	0455CRSD	2* ± 4	224	0.52[4]	--	23 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth
4. No statistical analyses were performed with these samples, because there was survival in only one replicate.

Protocol: EPS1/RM/xx, January 1997.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

22-jan-98

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
Biological control	76 ± 6	7	0.85 ± 0.05	6	4 Oct.
Biological control	78 ± 4	6	0.97 ± 0.09	9	22 Oct.
Biological control	90 ± 10	11	0.8 ± 0.11	14	23 Oct.
Biological control	84 ± 6	6	0.98 ± 0.08	8	29 Oct.
Biological control	84 ± 6	6	0.63 ± 0.12	19	31 Oct.
Biological control	76 ± 5	7	0.82 ± 0.09	11	1 Nov.
Biological control	78 ± 4	6	1.07 ± 0.12	11	5 Nov.
Biological control	90 ± 0	0	0.67 ± 0.05	7	6 Nov.
Biological control	76 ± 6	7	0.78 ± 0.03	4	7 Nov.
Biological control	94 ± 9	10	0.75 ± 0.05	6	14 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

19-jan-98

Approved by:

L Savoy

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MR1-S	0351HASD	82* ± 4	6	0.28 ± 0.09	34	12 Sept.
MR2-S	0352HASD	70* ± 7	10	0.26 ± 0.02	10	12 Sept.
MR3-S	0353HASD	80* ± 0	0	0.17* ± 0.03	17	12 Sept.
MR4-S	0354HASD	50* ± 0	0	0.22 ± 0.02	11	12 Sept.
MR5-S	0355HASD	74* ± 6	7	0.21 ± 0.02	11	12 Sept.
MR6-S	0356HASD	56* ± 6	10	0.17* ± 0.02	13	12 Sept.
MR7-S	0357HASD	62* ± 4	7	0.19 ± 0.02	12	12 Sept.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.
*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).
The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

19-jan-98

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7

Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MF1-S	0442HASD	50* ± 7	14	0.07*± 0.02	26	25 Sept.
MF2-S	0443HASD	20* ± 0	0	0.08* ± 0.05	63	25 Sept.
MF3-S	0444HASD	62* ± 4	7	0.11* ± 0.04	34	19 Sept.
MF4-S	0445HASD	62* ± 4	7	0.13* ± 0.02	16	19 Sept.
MF5-S	0446HASD	68* ± 4	7	0.11* ± 0.01	10	19 Sept.
MF6-S	0447HASD	24* ± 15	63	0.16* ± 0.05	34	19 Sept.
MF7-S	0448HASD	72* ± 4	6	0.18* ± 0.05	25	19 Sept.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.
*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).
The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

19-jan-98

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CERTIFICATE OF ANALYSIS

Client:	BEAK (Brampton)
Adresse:	14 Abacus rd Brampton, On L6T 5B7
Contact:	D. Farara/P. McKee
Project N° :	20776.230
Type of sample:	Sediment
Collected by:	BEAK (Brampton)
Method of transport:	Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MN4-S	0449HASD	0*	--	--	--	25 Sept.
MN5-S	0450HASD	6* ± 13	224	0.17[4]	--	19 Sept.
MN6-S	0451HASD	4* ± 6	137	0.12* ± 0.08	71	19 Sept.
MN7-S	0452HASD	2* ± 4	224	0.04[4]	--	25 Sept.
MN8-S	0453HASD	0*	--	--	--	25 Sept.
MN9-S	0454HASD	0*	--	--	--	25 Sept.
MN10-S	0455HASD	8* ± 11	137	0.06* ± 0.05	80	25 Sept.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth
4. No statistical analyses were performed with this sample, because there was survival in only one replicate.

Protocol: EPS1/RM/xx, December 1996.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

22-jan-98

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CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
Biological control	96 ± 6	6	0.25 ± 0.04	14	12 Sept.
Biological control	88 ± 8	10	0.26 ± 0.02	9	19 Sept.
Biological control	98 ± 4	5	0.26 ± 0.06	25	25 Sept.
Biological control	92 ± 8	9	0.24 ± 0.04	16	15 Oct.
Biological control	88 ± 8	10	0.26 ± 0.02	8	17 Oct.
Biological control	86 ± 6	6	0.26 ± 0.01	4	25 Oct.
Biological control	80 ± 0	0	0.3 ± 0.12	41	30 Oct.
Biological control	98 ± 11	11	0.41 ± 0.06	15	5 Nov.
Biological control	84 ± 6	6	0.28 ± 0.02	7	19 Nov.
Biological control	88 ± 4	5	0.25 ± 0.04	15	20 Nov.
Biological control	80 ± 0	0	0.25 ± 0.04	16	21 Nov.
Biological control (QAQC test)	80 ± 0	0	0.25 ± 0.02	7	28 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.

19-jan-98

Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

General informations regarding the sediment samples

Client:	BEAK International
Contact:	Dennis Farara / Paul McKee
Project N°:	20776.230
Type of sample:	Sediment
Method of transport:	Fedex

Sample	Received[1]	Characteristics	Treatment	Beginning of test	End of test
MR1-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	26/09/97[2] 14/09/97[3]
MR2-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	26/09/97[2] 14/09/97[3]
MR3-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	26/09/97[2] 14/09/97[3]
MR4-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	26/09/97[2] 14/09/97[3]
MR5-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 23/10/97[3]	12/09/97[2] 02/11/97[3]
MR6-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	12/09/97[2] 04/10/97[3]
MR7-S	11/09/97	Silt / clay composition	Homogeneisation	12/09/97[2] 04/10/97[3]	12/09/97[2] 04/10/97[3]
MF1-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 22/10/97[3]	09/10/97[2] 01/11/97[3]
MF2-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 22/10/97[3]	09/10/97[2] 01/11/97[3]
MF3-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 22/10/97[3]	03/10/97[2] 01/11/97[3]
MF4-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 22/10/97[3]	03/10/97[2] 01/11/97[3]
MF5-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 22/10/97[3]	03/10/97[2] 01/11/97[3]
MF6-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 22/10/97[3]	03/10/97[2] 01/11/97[3]
MF7-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 22/10/97[3]	03/10/97[2] 01/11/97[3]
MN4-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 04/10/97[3]	09/10/97[2] 14/10/97[3]
MN5-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 23/10/97[3]	03/10/97[2] 02/11/97[3]

Sample	Received[1]	Characteristics	Treatment	Beginning of test	End of test
MN6-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 23/10/97[3]	03/10/97[2] 02/11/97[3]
MN7-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN8-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN9-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN10-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
D1B-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D1B-2-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D1B-3-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-2-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-3-S	10/10/97	Silt / clay composition, odour	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-4-S	10/10/97	Silt / clay composition, odour	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D3-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D3-2-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-3-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-4-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-5-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-6-S	10/10/97	Silt / clay composition,	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-7-S	10/10/97	Silt / clay composition, surface of sediment is orange	Homogeneisation	25/10/97[2] 29/10/97[3]	08/11/97[2] 08/11/97[3]

Conditions and procedures for whole sediment testing with the freshwater midgefly larvae *Chironomus riparius*

Conditions and procedures	Env. Canada 1997[1]	BEAK International inc.
Test type	14 days, static or twice daily renewal	14 days, static
Water renewal	Static: none, except if evaporation occurs.	Static: none, except if evaporation occurs.
Overlying water	Dechlorinated culture water, uncontaminated ground water	Culture water originating from the city of Dorval aquaduct, and dechlorinated by a system devised by BEAK Dorval. Overlying surface water is aerated for 24 hrs prior to the start of tests.
Control sediment	Natural sediment exempt from natural or artifical contaminants, previously tested to ensure adequate growth and survival.	Natural sediment collected from Long Point (Lake Erie, ON) exempt from contaminants, provided by CCIW, Burlington, ON
Organisms	*Chironomus riparius*, ≤48hrs old, 10 organisms per beaker	*Chironomus riparius*, ≤48hrs old, 10 organisms per beaker
Test beakers	300 mL glass beakers, with covers	300 mL glass beakers, with covers
Volume of sediment (wet)	100 mL	100 mL
Volume of overlying water	175 mL	175 mL
Number of replicates	A minimum of 5 field replicates, and 1 to 5 replicates for each field replicate	5 replicates per sample
Temperature	daily average: 23±1°C instant: 23±3°C	23±1°C: Temperature of water bath taken daily, temperature of 1 replicate from each sample taken 3 times/wk
Lighting and photoperiod	• fluorescent tubes that provide 500-1000 lux • photoperiode: 16 h light-8 h dark	• fluorescent tubes that provide 630-1000 lux • photoperiode: 16 h light-8 h dark

1: Conditions and procedures recommended by: Environment Canada. January 1997. Test for growth and survival in sediment using larvae of freshwater midges (*Chironomus tentans* or *Chironomus riparius*)- Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Conditions and procedures	Env. Canada 1997[1]	BEAK International inc.
Aeration	static: continuous aeration (2 - 3 bubbles /sec in all beakers)	static: continuous aeration (2 - 3 bubbles /sec in all beakers)
Feeding regime	Fish food flakes (Tetrafin™ or Nutrafin™ : 4 times/week, 15 mg (dry weight) in a 3.75 mL suspension/beaker or daily with 6.0 mg (dry weight) in a 1.5 mL suspension/beaker .	Fish food flakes (Nutrafin™) : 4 times/week, 15 mg (dry weight) in a 3.75 mL suspension/beaker.
Observations	Optional: number of organisms observed at the sediment surface, general behaviour (daily or less frequently).	Daily observations of each beaker, if organisms are observed, it is noted.
Parameters: overlying water	• DO and temperature: ≥3 times/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample	• DO and temperature: 3 times/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample
Test endpoint	Growth and survival: mean % survival and mean dry weight/organism for each sample	Growth and survival: mean % survival and mean dry weight/organism for each sample
Test validity	Test invalid if the mean survival in the control is less than 70% and/or if the mean dry weight per organisms is less than 0.5 mg.	Test invalid if the mean survival in the control is less than 70% and/or if the mean dry weight per organisms is less than 0.5 mg.
Reference toxicant	Water only 96 hrs test using $CuSO_4$, $CdCl_2$, KCl or NaCl . Minimum of five concentrations and a control, with 3 replicates.	Water only 96 hrs test using $CuSO_4$, $CdCl_2$, KCl or NaCl . Minimum of five concentrations and a control, with 3 replicates. • Reference toxicant: $CuSO_4$ • Geometric mean and standard deviation: CL_{50}: 0,19 ppm (0.04) Coefficient of variation: 22%

1: Test conditions and prodedures recommended by Environment Canada. January 1997. Test for growth and survival in sediment using larvae of freshwater midges (*Chironomus tentans* or *Chironomus riparius*)- Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Quality Control Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
MF6-S	0447HASD	24* ± 15	63	0.16* ± 0.05	34	19 Sept.
D1B-2-S	0467HASD	84 ± 15	18	0.14* ± 0.03	24	15 Oct.
D3-1-S	0473HASD	52* ± 31	60	0.10* ± 0.01	11	15 Oct.
MMS4-3	0492HASD	30* ± 27	91	0.27* ± 0.04	16	5 Nov.
MMS3-1	0496HASD	86 ± 11	13	0.16 ± 0.03	22	30 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

Quality control:

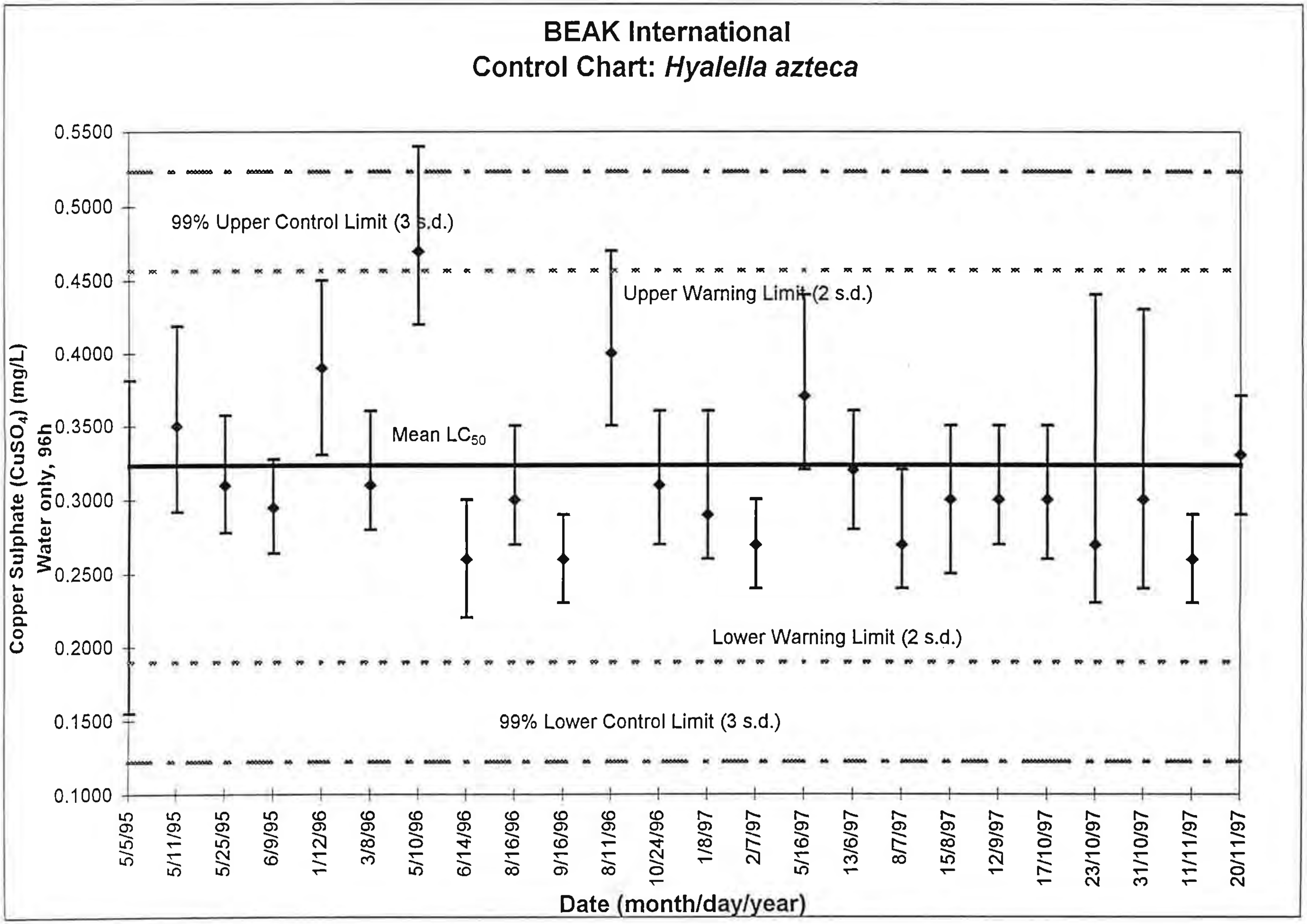
Sample **MF6-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 22* ± 20, C.V.(%): 93
Growth (mg/organism): 0.14* ± 0.03, C.V. (%): 18

Sample **D1B-2-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 74 ± 6, C.V.(%): 7
Growth (mg/organism): 0.14* ± 0.02, C.V. (%): 17

Sample **D3-1-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 42* ± 16, C.V.(%): 39
Growth (mg/organism): 0.09* ± 0.01, C.V. (%): 16

Sample **MMS4-3** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 16* ± 26, C.V.(%): 163
Growth (mg/organism): 0.09* ± 0.02, C.V. (%): 22

For the sample **MMS3-1**, a test was performed the 05 November 1997, but there was contamination (fungus observed on surface of sediment), so it was re-tested on the 28 November 1997:
Survival (%): 92 ± 13, C.V.(%): 14
Growth (mg/organism): 0.23 ± 0.03, C.V. (%): 15



BEAK International
Control Chart: Hyalella azteca
Copper Sulphate (CuSO4) (mg/L) Water only, 96h
0.5500
0.5000
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
99% Upper Control Limit (3 s.d.)
Upper Warning Limit (2 s.d.)
Mean LC50
Lower Warning Limit (2 s.d.)
99% Lower Control Limit (3 s.d.)
5/5/95
5/11/95
5/25/95
6/9/95
1/12/96
3/8/96
5/10/96
6/14/96
8/16/96
9/16/96
8/11/96
10/24/96
1/8/97
2/7/97
5/16/97
13/6/97
8/7/97
15/8/97
12/9/97
17/10/97
23/10/97
31/10/97
11/11/97
20/11/97
Date (month/day/year)